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# APPLIED MECHANICS Reviews

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# APPLIED MECHANICS REVIEWS

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## NEW EDITOR FOR AMR

Our new masthead now reflects the actual editorial operations at Southwest Research Institute. Stephen Juhasz, after seven years as executive editor, now becomes Editor.

Fortunately, the services of Martin Goland, AMR's editor for ten years, are not entirely lost to us. In assuming his new responsibilities as President of SWRI, he felt that he must relinquish his position as editor, but will remain with AMR in the capacity of Editorial Advisor.

ASME, as publisher of an eminently successful journal, owes much to both Martin Goland and Stephen Juhasz for bringing AMR to its present position as the leading review journal of the world in the field of applied mechanics.

S. A. Tucker,

For the publisher,
The American Society of Mechanical Engineers

# REVIEW OF PANEL FLUTTER AND EFFECTS OF AERODYNAMIC NOISE

PART I: PANEL FLUTTER

by

L. E. GOODMAN AND J. V. RATTAYYA

UNIVERSITY OF MINNESOTA, MINNEAPOLIS, MINNESOTA

## INTRODUCTION

With the development of high-speed aircraft and missiles, vibration of panels has become a problem of practical significance. Many of the failures of the early German rockets after attaining supersonic speed have been attributed to the development of such panel oscillations. It appears this phenomenon is not of much concern in the subsonic speed range; however, in the supersonic speed range panels may develop oscillations which cause instability of the structure. This effect has been exhibited experimentally under controlled laboratory conditions (8,23). Owing to edge restraints the maximum amplitude of panel motion is limited and buckling may not be a serious design problem. In these cases panel flutter is still of importance because of its effect on the fatigue life and the allowable stresses for design of the panel material.

The oscillations of panels may be due either to aerodynamic force induced by the motion of the panel, or to aerodynamic noise, or buffeting (irregular motion induced by turbulence in the flow). The interaction between aerodynamic forces and panel motions, usually referred to as "panel flutter," has been investigated by several workers in recent years. Since the problem is too complex to be dealt with in its entirety, simplifying assumptions have been made in these investigations. The literature is marked by a certain degree of controversy over the validity of these assumptions and the applicability of the results obtained. A brief review of the literature with reference to several of the approximations made and the results obtained follows.

## PANEL FLUTTER

The problem of a two-dimensional flat or slightly curved panel of a finite chord length, held at its leading and trailing edges, with a supersonic stream on its upper surface has been treated in references (1-5)[1]. In all these investigations it has been assumed that the panel deflection is such that small-deflection plate theory and two-dimensional linearized flow theory can be safely used to determine pressure distribution on the surface of the panel. Attempts have been made in all these references to establish the stability boundaries beyond which the panels become unstable due to flutter and to obtain the panel thickness required to avoid such flutter. Isaacs (1) and Fung (4) consider the static stability of the curved panel (postbuckling analysis) and suggest that flutter occurs as soon as static equilibrium is not possible. According to this concept, the panel begins to vibrate when the dynamic pressure is so high that no stable static equilibrium configuration exists. This motion cannot itself be stable since the assumption of the existence of any static equilibrium configuration after a lapse of time leads to a contradiction. Further, since the inertia forces are not considered in this investigation, it is quite possible to have unstable oscillations at pressures even less than those for which there is no stable static equilibrium configuration. The critical value of dynamic pressure obtained in this way determines the upper bound above which the static equilibrium becomes unstable.

Hayes (2) considers the dynamic stability of a buckled panel using the steady-state air forces. Miles (3) treats the same problem with quasi-stationary air forces which include the first power of the frequency of oscillation and finds that all panels, regardless of thickness, are unstable for Mach number $M$ in the range $1 < M < \sqrt{2}$. Shen (5), avoiding limitations on the order of frequency, uses exact linearized unsteady aerodynamic forces and finds that stability is possible only for a small range of panel thickness at $M = \sqrt{2}$. He points out the necessity of including higher-order frequency terms in Miles's treatment at Mach number $\sqrt{2}$. All these references (2,3,5) employ a generalized-coordinate approach involving selected modes of the panel as degrees of freedom.

The analyses of Isaacs, Hayes and Miles (1-3) assume the amplitude of buckle is large compared with panel thickness and do not take into account the change in length of the panel due to axial thrust. The results obtained indicate that a finite critical dynamic pressure for static stability exists regardless of the initial amplitude of the buckle. Fung (4) takes into account the middle-plane stresses and strains and re-examines the static equilibrium of a simply supported panel. He not only confirms the existence of a critical Mach number above which a bent panel cannot maintain static equilibrium but also establishes the dependence of the critical pressure on the initial amplitude of the buckle. In this analysis the edges of the panel are taken as hinged, one fixed in position and the other restrained by spring. Von Karman's large deflection equations, generalized to initially curved plates, together with

[1]Numbers in parentheses refer to the Bibliography at the end of the paper. This work has been supported by the Directorate of Laboratories, Wright Air Development Center, Dayton, O.

linearized aerodynamic theory, are used. One remarkable conclusion of this analysis is that the critical dynamic pressure tends to zero for a buckled panel with vanishing initial amplitude of buckling. An application of these results to the flutter of a flat panel in the presence of thermal buckling is discussed. It is shown that if the panel is to be flutter-free, only thermal buckling of a *sudden* nature, such as that associated with thermal shock, can be tolerated.

A further extension of the work reported in (2,3,5) has been carried out by Nelson and Cunningham (7). They have developed a Rayleigh flutter analysis using Galerkin's process for a two-dimensional flat panel held in various ways at its leading and trailing edges and acted on by middle-plane forces. The upper surface is subjected to a moving supersonic stream. The lower surface is in contact with an otherwise unconfined mass of stationary compressible air, the influence of which has been neglected in earlier treatments. Using the normal modes of the panel (without middle-plane forces) as degrees of freedom, and making use of linearized unsteady aerodynamic forces, numerical results are obtained. The effects of number of modes considered, Mach number, density of the supersonic stream, density of still air below the panel, panel mass and stiffness and structural damping are examined to a certain extent. For example, middle-plane tension is shown to have a markedly favorable effect at $M = 1.3$ in reducing the thickness required to prevent flutter. Small amounts of structural damping are found to have a beneficial effect near and below $M = \sqrt{2}$ and no effect at $M = 1.56$. Still air below the panel has a moderately beneficial effect at $M = 1.3$ and little effect for $M > \sqrt{2}$. In the neighborhood of $M = \sqrt{2}$ a small change in either Mach number or structural damping is found to cause an abrupt change in the thickness required to prevent flutter. The stability boundaries at $M = 1.3$ and 1.56 do have the contrasting behavior corresponding to the transition at $M = \sqrt{2}$ obtained by Miles (3). In general, the results indicate the low supersonic Mach number range is critical from the design standpoint and that sufficiently thick panels are flutter free throughout the supersonic speed range.

In an effort to elucidate the behavior near $M = \sqrt{2}$ an analysis of a two-dimensional panel on many equally spaced simple supports with supersonic flow above and still air below has been performed in reference 9. This configuration is claimed to approximate design conditions more closely than does a panel of finite chord length. In this analysis spatial periodicity over two bays has been assumed in choosing deflection functions and unsteady linearized compressible flow theory is employed for air forces. Further, anticipating rapid convergence, the deflection is approximated by two functions, $\sin 2\pi\, x/L$ and $(1 - \cos 2\pi\, x/L)$. According to this analysis instability is predicted for all $1 < M < 1.25$. Moreover, the stability boundaries exhibit as many as four branches.

Noticing the analogy of the panel flutter problem to the classical problem of the generation of water waves (Kelvin) by wind and to that of the fluttering of flags and sails (Rayleigh), Miles carries out panel flutter analysis by studying the progressive waves in a plate which is immersed in a flow. He points out that in such a plate a straight-crested progressive wave interacts with the flow in such a way that a critical flow speed exists above which the wave amplitude will diverge with increasing time and below which it damps out. He obtains the stability boundaries which indicate that the stiffness required to prevent instability increases monotonically both with mass parameter (air density × wave length/panel mass per unit area) and with Mach number. Further, a very steep rise in required thickness is predicted for a small change in Mach number at relatively short wavelengths. At very large wavelengths the required thickness becomes independent of $M$. These results are fundamentally different from the earlier conclusions (3,5,9). Miles has criticized the earlier treatments as inadequate. In particular, the validity of the spatial periodicity and the choice of the deflection modes $\sin 2\pi\, x/L$ and $(1 - \cos 2\pi\, x/L)$ as against the mode $\sin \pi\, x/L$ in reference 9 have been questioned. According to Miles, the functions $(1 - \cos 2n\pi\, x/L)$ which satisfy the boundary conditions but not the differential equation are not admissible as natural modes of the freely vibrating panel. Therefore the rapid convergence of the cosine portion of the series in the analysis is doubtful. Another objection raised by Miles is that Rayleigh-Galerkin type of approximation may have been pushed beyond its useful limits in earlier cases, e.g. (3,5).

The criticism advanced by Miles (10) against the assumed spatial periodicity of deflection and the neglect of the term $\sin \pi\, x/L$ in (9) has been answered in (16). The unsteady linearized compressible flow theory used earlier has been replaced by the simple "static" air force approximation of Hayes used in (14). Making use of the exact solution obtained in (14) and satisfying the boundary conditions of (a) zero deflection at the supports, (b) continuous slope and moments across the supports, and (c) finiteness of the deflection at both ends ($x = \pm\infty$), it is shown that the deflections in the $n + 2$ bay must be the same as those in the $n$th bay. This confirms the validity of the spatial symmetry over two bays that was assumed in the earlier investigation. Miles's stability criterion (10) has been criticized as prohibitively conservative for a practical basis for design at high Mach numbers.

Rodden considers a periodically supported infinite panel and obtains an explicit stability boundary for a two-mode analysis in (32). The results obtained are explained in an especially cogent form. They agree with those of (9). The results for a two-bay continuous panel, also analyzed in (32) at $M = 1.56$ and $M = 2$, seem to support the choice of mode shapes used in (9) and which had been disputed earlier. An explanation of the apparent conflict among discussers of the results obtained in (9), (10), and (16) has been offered in (33). Miles and Rodden define two different types of instability—single-degree-of-freedom instability and coupled mode instability—and point out that the instability discussed in (10) is of the first type, whereas the one considered in (16) is of the other type. They also remark that single-degree-of-freedom instability is especially likely in $1 < M < \sqrt{2}$ if the reduced frequency (circular frequency multiplied by chord length and divided by the product of $\pi$ and the speed of sound) is less than $M - 1$.

The flutter analysis of an infinite panel which is considered in (10) and in (25) and (26) neglects the presence of a boundary layer on the panel surface. The influence of the presence of a boundary layer is qualitatively examined in (37). One important consequence of the inclusion of this physical feature seems to be a reduction, by an order of magnitude, of the degree of instability predicted in (10).

A short investigation of the stability of travelling waves in an ideal homogeneous thin panel has been reported by Jordan (11). Assuming the aerodynamic forces are proportional to the local slope of the panel, the critical flutter speed is shown to be equal to the wave speed which, in still air, would have a wavelength equal to that of the plate. It is claimed that this result is in agreement with wind-tunnel tests on paper panels. Experimental evidence is also cited to the effect that among all the possible patterns having a critical speed below the given air speed, the one having the shortest wavelength will prevail. This fact leads to the inference that the amplitude of flutter decreases as air speed increases and that a stage will be reached where, in virtue of the very small amplitudes present, the panel will be safe even though it is unstable in the usual sense. In support of this argument reference is made to a paper panel tested for $3.5 < M < 5.0$ and found undamaged. In view of the small number of models tested, no claim of extensive reliability is advanced by Jordan.

Goland and Luke (6) treat the problem of a vibrating membrane in a supersonic stream by the method of Laplace transform. It is found that flutter cannot occur (for the membrane) at high supersonic Mach numbers. The plate or panel problem

is considered to be very similar to the membrane problem and consequently the authors of reference 6 have suggested that a similar result may hold for the panel problem also. These conclusions are questioned by Shen (12) and Hedgepeth (14). Following physical reasoning, Shen makes plausible the existence of modes in which the panel is capable of self-excited simple harmonic motion for all values of a parameter $\gamma$ which contains $M$ as a factor. This contradicts the main result of reference 6, namely that for $\gamma >> 1$, there is no such mode, i.e. flutter cannot occur. Analytically, the inadequacy of a limiting process used in (6) has been pointed out by Shen. To avoid misleading interpretations of analytical results, it is necessary to establish the existence of divergent motion on one side of the flutter boundary. An investigation in this direction is reported in (13) where panel flutter is formulated as a complex eigenvalue problem.

In their analysis for pressure distribution Goland and Luke use the expression given by Miles for an oscillating airfoil (15). Hedgepeth (14) has replaced this by the "static" approximation of Hayes and has explained, for the first time, the qualitatively dissimilar behavior of plates and membranes at high Mach numbers. According to this analysis, plate panels flutter at high supersonic Mach numbers while membranes do not. This confirms the other analyses of membranes but contradicts that for plates obtained earlier in reference 6. The convergence of Galerkin's method has also been made plausible by taking first two and then three natural modes as degrees of freedom defining the deflection.

In a second approach to the panel flutter problem Fung examined the dynamic stability of static equilibrium configurations for infinitesimal perturbations (21). Miles's low-frequency approximation to aerodynamic forces has been used. Results of the analysis for flat plates have indicated that dynamic stability is possible if the dynamic pressure lies between certain finite limits and if the size of the buckle in the absence of aerodynamic forces would be small. Fung's results for curved panels agree with those of Miles in predicting dynamic instability only for dynamic pressure in excess of a critical value prescribed by the requirements needed for static equilibrium and only for $M > \sqrt{2}$. Fung also advances a method for estimating the limiting amplitudes of flutter.

The foregoing analysis has been extended by Eisley (23) who replaced the simply-supported edge conditions by clamped edge conditions. The flutter mode is represented by a series of Iguchi functions. Eisley reports on tests conducted in order to check the assumptions of the theory. The test results are compared with numerical values obtained by retaining only the first two of the assumed functions. In these tests the leading and trailing edges of the panel have been fastened with screws and the other two edges freed so as to provide a close approximation to the two-dimensional panel with clamped edges. Provision was made to vary the amplitude of the buckle by varying the amount of edge compression. In the experiments, the amplitude of the buckle was gradually increased and the compression recorded at onset of flutter. A comparison of results at $M = 2.18$ indicates that use of higher modes in theory is probably necessary. The assumptions made in the analysis seem, on the whole, to be justified, and the dependence of the critical flutter condition on the amount of edge compression is established.

In another series of experiments (8) Sylvester and Baker have demonstrated the existence of panel flutter at $M = 1.3$. They have also studied the effects of certain structural parameters on flutter characteristics. The panel configurations tested were (a) panels clamped front and rear with tension, (b) buckled panels clamped front and rear, and (c) buckled panels with all edges clamped. The experiments have indicated that the last configuration is much less prone to flutter than are buckled panels clamped only at the front and rear, especially when the panel is simply buckled (one hump). Increase of tensile load or bending stiffness of the plate, as well as shortening of panels, appeared to be effective in eliminating flutter. The pressure differential across the plate was observed to have a stabilizing effect.

A comparison of theoretical predictions (made on the assumption that the plates are perfectly flat in the unstressed state) with the experimental results of Eisley shows a large discrepancy in the stability boundaries. Fung (22) attempts to explain this discrepancy by considering the effects of the initial curvature and of a static pressure differential across the plate. It appears that the discrepancy, in the case of large amplitude flutter, can be accounted for by small initial deviation of the plate from perfect flatness. The static pressure differential across the plate, when it is sufficiently large, is shown to be very effective in preventing flutter. This analysis however does not account for the small amplitude flutter which occurred in the experiments. In reference (24) the two-dimensional panel flutter problem is presented, with all the refinements made known in earlier investigations. The equations governing the deflection surfaces before and after the aerodynamic pressure acts on the plate have been written down and then solved (approximately) by Galerkin's method for two-dimensional panels with pinned and clamped edges. Stability boundaries are presented for (a) initially flat plates, (b) initially warped plates, with two-term approximations for the deflection surfaces. The effect on the stability boundary of a static pressure differential across the plate is studied and is observed to increase the critical value of the 'reduced velocity,' of the plate. The experiments conducted by Eisley (23) approximate closely the assumptions made in Fung's treatment. From a knowledge of these experiments Fung describes the qualitative nature of the flutter phenomenon as follows: There are two distinct types of oscillation, (a) irregular and small-amplitude motion at small amplitudes of buckle and (b) large-amplitude oscillation which is nearly harmonic in its time variation. As the amplitude of the buckle is increased from zero, small-amplitude motion first sets in. At one stage it disappears and with further increase of the amplitude of buckle the large-amplitude motion starts. Once this latter phase starts it cannot be stopped by further increase in the amplitude of the buckle.

For critical comparison of his analysis with experimental results Fung points out the necessity of considering the effects of various simplifications assumed in the analysis and the possible deviations of the experimental apparatus from ideal conditions. Considering the effect of initial warping and buckling amplitude as secondary influences, he characterizes the panel flutter of a buckled plate at a sufficiently high Mach number by a constant critical value of dynamic pressure ratio (dynamic pressure/$D\pi^4\sqrt{M^2-1}$, where $D$ = plate stiffness).

As remarked earlier, the validity of Galerkin's method as applied to the panel flutter was questioned by Miles. Though it is widely used, no mathematical foundation has been given for its application to this problem. Fung has attempted (24) to check its validity by solving the panel flutter problem in a more rigorous method and comparing the two results. He formulates the flutter problem in the form of an integral equation and solves it numerically by iteration. For plates with finite bending stiffness it is found Galerkin's method gives satisfactory results. This confirms the earlier investigation of Hedgepeth (14).

The experiments also show that the amplitude of panel flutter does not grow indefinitely but develops a limiting cycle. An approximate analysis for the possible occurrence of such a limiting cycle is also discussed by Fung (24).

All the investigators so far mentioned, with the exception of Miles and Jordan who treat an infinite panel, have considered panels of infinite span and finite chord either on two or many equally spaced supports arranged at right angles to the direction of flow. The flutter of panels of finite dimensions is considered in references (17–20). References 17, 18 and

19 use modal solutions and present numerical results for a variety of panel aspect ratios over a limited range of supersonic Mach numbers. Eisley (17) uses linearized two-dimensional unsteady flow theory and solves the problem of a simply-supported rectangular plate. Strip theory and air forces linearized in terms of reduced frequency are made use of to simplify results in a particular case. Luke et al (18,19) employ three-dimensional theory and solve the problem of an infinite-span panel separated into rectangular bays by equally spaced rigid streamwise stiffeners. In these analyses the stresses in the midplane are not considered. Hedgepeth (20) uses the so-called "static" air forces and solves the problem of an isolated simply-supported rectangular panel of uniform thickness with midplane forces acting. In the "static" air force concept, no time-dependent effects are considered in pressure-potential relations and the loading corresponds to that which would result from flow over a stationary surface with shape the same as that of the deflected plate at that instant. This is simple to treat and yields almost the same flutter boundaries obtained by means of unsteady aerodynamic theories, at least for high Mach numbers. The comparison of these results with those of Eisley for unstressed plates suggests that the lower limit above which this "static" air force concept yields good results is somewhere between $\sqrt{2}$ and 2. Some conclusions regarding the effect of aspect ratio of panels on panel thickness required to prevent flutter are arrived at in this analysis (20). In general it is found that the influence of finite aspect ratio on panel thickness is very small. For square panels the panel thickness increases monotonically with Mach number. It may be recalled that in the earlier investigations the panel thickness for infinite span panels was found to have a critical value at $M = 1.3$, this value being almost four times as large as that at $M = 6$. Actually, the thickness decreases rapidly between $M = 1.3$ and 1.5 and then increases slowly, for these infinite-span panels.

In order to check the convergence of the modal approach, Hedgepeth (20) has solved the above problem in two ways, (a) as the limiting case of an infinite span panel and (b) by the Galerkin procedure, using only finite number of modes to present the deflection of the panel. The first method yields an exact solution. Four-term approximation in the second method seems to give satisfactory results.

The analysis of the aerodynamic instability of travelling waves applied to an infinite flat panel in (10) has been extended to an infinite cylindrical shell exposed to supersonic flow and containing an internal fluid (25-26). In order to approximate this shell by a plane for purposes of analysis the following assumptions are made: (a) the thickness of the shell wall is small compared with the mean radius and (b) the radius of the shell surface is everywhere large compared with the wavelength. Flutter of infinitely long unstiffened and ring-stiffened circular cylinders is also studied in (27). In this analysis, the midplane tensile stresses and a small amount of structural damping are taken into account. Donnell's theory is assumed valid and where the condition of a large number of circumferential waves is not met a simplified version of Flügge's cylinder theory is employed to improve the accuracy of the results. Air forces are predicted by linearized unsteady potential flow theory and stability is characterized by damped or purely sinusoidal motion, instability by motion increasing in amplitude. For unstiffened thin cylinders it is shown that the only instability at subsonic speeds is static divergence. At supersonic speeds flutter is the only instability. On the other hand, for ring-stiffened cylinders, both divergence and flutter are possible at supersonic speeds. It appears that structural damping and internal fluid are important factors in the analysis of unstiffened cylinders. The internal fluid has a destabilizing effect and, in fact, the anomalous result is reported that "for Mach numbers greater than one plus the ratio of the speeds of sound in the fluids inside and outside the cylinder, no adjustment of the physical properties of the cylinder will make it stable."

One of the difficulties encountered in solving the problems of aeroelasticity is the complex way in which the exact unsteady aerodynamic forces are obtained. Any simplified theory which yields sufficiently accurate aerodynamic forces will be a great asset in the solution of these problems. For small amplitudes of unsteady motion and for high Mach numbers "piston theory" predicts a point-function relationship between the local pressure on the oscillating surface and the normal component of fluid velocity produced by such oscillation. The application and simplicity of this concept as applied to panel flutter problems has been demonstrated in (28).

Linear piston theory has been used to solve the flutter problems of the flat, simply-supported, two-dimensional panel and the elliptic clamped-edge panel (28a). The method of attack is the same as that employed in (7) except for the fact that linearized unsteady flow theory has been replaced by piston theory. Pressure variation underneath the panel is neglected in this investigation. Stability boundaries and critical panel thickness as a function of Mach number are obtained for the simply-supported two-dimensional panel with no axial tension and zero structural damping, using the first two modes. The neglect of damping is shown to be justified. This theory is then compared with earlier results (20,7,3 and 1). At $M = 2$ the analysis is extended by the use of two additional modes to confirm the result of (7) that the two-mode solution gives a conservative estimate for the critical panel thickness. The modes assumed in the case of the elliptic clamped-edge panel correspond to deflection shapes due to pressure loadings of the form $p$ (const) and $px$. For rough comparison, the panel with $a/b = 0$ ($a/b$ is the ratio of the axis of the ellipse in the flow direction to that in the perpendicular direction) is approximated by a two-dimensional case and the panel with $a/b = 1$ by a square panel, and some confirming results as to critical panel thickness are derived. These are (a) for unstressed panels the critical panel thickness ratio does not change greatly for panel aspect ratio larger than unity and $M > \sqrt{2}$; (b) the ratio of critical thicknesses for simply-supported and clamped-edge two-dimensional panels is $\cong 1.3$. It may be recalled here that a result similar to that of (a) was obtained by Hedgepeth (20) for rectangular simply-supported panels and that (b) agrees approximately with a similar result obtained in (7). Two other conclusions drawn from this analysis are that Ackeret loading seems to be more exact than piston theory for panel flutter analyses at low Mach numbers and that within the limitations of piston theory the flutter boundary is not a function of the angle of incidence of the panel.

A two-dimensional membrane problem with upper side exposed to supersonic airstream and lower surface subjected to free-stream pressure has been solved by Hains (29). The air pressures are obtained by piston theory in which second- and third-order terms in the pressure relation are retained. To solve the resulting nonlinear differential equation, a numerical method based on the method of characteristics is suggested. This procedure is claimed by the authors of (29) to offer more physical insight into the nature of panel oscillation than do alternative procedures.

It has been pointed out earlier that the low supersonic Mach number range $1 < M < \sqrt{2}$ is critical for panel flutter. In this range earlier analyses indicated a steep rise in the panel thickness required to prevent flutter at lower Mach numbers. This anomalous result has been attributed to the inadequacy of the aerodynamic theories used. In (35), linearized flow theory suggested by Lin, Reissner and Tsien (34) has been used to obtain an expression for the pressure on the vibrating panel. The flutter analysis has been extended down to $M = 1$ for panels with both edges simply supported or both edges

clamped, midplane tension being considered in each case. This theory is valid, however, only when the "reduced frequency" lies within certain limits. The "reduced frequency" used by the author of (35) is defined as the product of the (circular) flutter frequency and the semichord length divided by the free-stream velocity. This parameter must be of the order of unity and must be much larger than both $\sqrt{(M^2-1)}$ and the ratio of the amplitude of motion to the chord length, raised to the two-thirds power. Also this amplitude ratio must be much smaller than unity. A brief discussion of experiments designed to permit study of the flutter of two-dimensional flat panels in the transonic range is also given in (35).

An approximate analysis of the nonlinear flutter problem based on the concept of "harmonic balance" is presented in (36). In this analysis a nonlinear system, in essence, is reduced to an equivalent linear one whose behavior can easily be found. As an illustration of the technique, Fung's finite amplitude flutter problem for a buckled panel (21) is re-solved. It is in this way reduced to the linear problem treated by Hedgepeth (20).

Another question of practical importance concerns the flutter of a conical or tapered cylindrical shell. The natural frequencies of such shells are reported in (38). Comparison of these results with those for a straight cylinder indicate the expected conicity effects. The stability of conical shells loaded axially and transversely is given in (39).

A reciprocity relation between the generalized forces, applicable in two-dimensional panel flutter problems, has been given in reference (30).

As has been indicated, a large amount of work has been done on the flutter of infinitely long two-dimensional panels and on simply-supported finite aspect ratio rectangular panels. This work can be extended to finite aspect-ratio rectangular panels with other edge conditions, e.g. (a) all four edges clamped, (b) two opposite edges clamped and the other two simply supported. No aircraft panel is either clamped or simply supported in the strict sense, rather it is elastically restrained. Consequently the analysis of flutter for elastically restrained panels is bound to be of practical interest. In (31) the natural frequencies of rectangular plates with elastically restrained edges are considered and a special case of a square plate restrained equally on all four edges is solved.

The geometry of aircraft panels does not restrict them to rectangular shapes alone. Circular shape panels are commonly used for windows and cut-outs. The analysis of such panels subjected to compressible supersonic flow on one surface would also be of practical interest.

## REFERENCES


1 Isaacs, R. P., Transtability flutter of supersonic aircraft panels, U. S. Air Force Project, Rand P-101, The Rand Corp., July 1, 1949.

2 Hayes, W. D., A buckled plate in a supersonic stream, North American Aviation, Inc., Rep. no. AL-1029, May 10, 1950.

3 Miles, J. W., Dynamic chordwise stability at supersonic speeds, North American Aviation, Inc., Rep. no. AL-1140, Oct. 18, 1950.

4 Fung, Y. C., The static stability of a two-dimensional curved panel in a supersonic flow, with an application to panel flutter, *J. Aero. Sci.* **21**, no. 8, Aug. 1954; AMR **8**(1955), Rev. 1333.

5 Shen, S. F., Flutter of a two-dimensional simply-supported uniform panel in a supersonic stream, M. I. T., Dept. Aero. Engng., Office of Naval Research Contract no. N 5 ori-07833, Aug. 6, 1952.

6 Goland, M., and Luke, Y. L., An exact solution for two-dimensional linear panel flutter at supersonic speeds, *J. Aero. Sci.* Apr. 1954; AMR **8**(1955), Rev. 474.

7 Nelson, H. C., and Cunningham, H. J., Theoretical investigation of flutter of two-dimensional flat panels with one surface exposed to supersonic potential flow, *NACA TN* 3465.

8 Sylvester, M. A., and Baker, J. E., Some experimental studies of panel flutter at Mach number 1.3, *NACA TN* 3914; AMR **10**(1957), Rev. 4122.

9 Hedgepeth, J. M., Budiansky, B., and Leonard, R. W., Analysis of flutter in compressible flow of a panel on many supports, *J. Aero. Sci.* **21**, no. 7, July 1954; AMR **8**(1955), Rev. 757.

10 Miles, J. W., On the aerodynamic instability of thin panels, *J. Aero. Sci.* **23**, 8, 771-780, Aug. 1956.

11 Jordan, P. F., The physical nature of panel flutter, *Aero Digest* p. 34-38, Feb. 1956.

12 Shen, S. F., Remarks on "An exact solution for two-dimensional linear panel flutter at supersonic speeds," *J. Aero. Sci.* Sept. 1955; AMR **10**(1957), Rev. 833.

13 Shen, S. F., Supersonic flutter of two-dimensional panels, Paper presented at the Supersonic Conference, co-sponsored by the University of Maryland and the Institute of the Aeronautical Sciences, University of Maryland, College Park, Md., May 19-20, 1954.

14 Hedgepeth, J. M., On the flutter of panels at high Mach numbers, *J. Aero. Sci.* June 1956.

15 Miles, J. W., The aerodynamic forces on the oscillating airfoil at supersonic speeds, *J. Aero. Sci.* June 1947.

16 Leonard, R. W., and Hedgepeth, J. M., On the flutter of infinitely long panels on many supports, *J. Aero. Sci.* May 1957; AMR **11**(1958), Rev. 957.

17 Eisley, J. G., The flutter of simply-supported rectangular plates in a supersonic flow, GALCIT Rep. no. OSR-TN-55-236, July 1955; AMR **9**(1956), Rev. 1922.

18 Luke, Y. L., St. John, A. D., and Gross, B., Panel flutter at supersonic speeds, Midwest Research Institute, WADC Contract AF 33(616)-2897: Third Quart. Prog. Rep., Mar. 29, 1956, Fourth Quart. Prog. Rep., May 29, 1956.

19 Luke, Y. L., and St. John, A. D., Panel flutter at supersonic speeds, Midwest Research Institute, WADC Contract AF 33(616)-2897: Fifth Quart. Prog. Rept., Oct. 31, 1956.

20 Hedgepeth, J. M., Flutter of rectangular simply supported panels at high supersonic speeds, *J. Aero. Sci.* Aug. 1957; AMR **11**(1958), Rev. 3190.

21 Fung, Y. C., The flutter of a buckled plate in a supersonic flow, GALCIT Rep. OSR TN 55-237, July 1955; AMR **9**(1956), Rev. 1558.

22 Fung, Y. C., Flutter of curved plates with edge compression in a supersonic flow, Proc. Midwest Conference on Fluid and Solid Mechanics, Ann Arbor, Mich., Apr. 1957 (OSR TN 57-187); AMR **11**(1958), Rev. 3192.

23 Eisley, J. G., The flutter of a two-dimensional buckled plate with clamped edges in a supersonic flow, Ph.D. Thesis, Guggenheim Aero. Lab., Calif. Inst. Technol., July 1956 (OSR TN 56-296).

24 Fung, Y. C., On two-dimensional panel flutter, *J. Aero. Sci.* Mar. 1958; AMR **11**(1958), Rev. 3703.

25 Miles, J. W., Supersonic flutter of a cylindrical shell, *J. Aero. Sci.* Feb. 1957; AMR **11**(1958), Rev. 256.

26 Ibid, Part II, *J. Aero. Sci.* May 1958; AMR **12**(1959), Rev. 6343.

27 Leonard, R. W., and Hedgepeth, J. M., On panel flutter and divergence of infinitely long unstiffened and ring stiffened thin walled circular cylinders, *NACA TN* 3638, Apr. 1956; AMR **9**(1956), Rev. 3337.

28 Ashley, H., and Zartarian, G., Piston theory—a new aerodynamic tool for the aeroelastician, *J. Aero. Sci.* **23**, 12, 1109-1118, Dec. 1956; AMR **10**(1957), Rev. 2630.

28a Johns, D. J., Some panel-flutter studies using piston theory, *J. Aero. Sci.* **25**, 11, 679-684, Nov. 1958; AMR **12**(1959), Rev. 4161.

29 Hains, F. D., Flutter of a thin membrane in hypersonic flow, *J. Aero. Sci.* **25**, 9, p. 595, Sept. 1958; AMR **12**(1959), Rev. 3636.

30 Miles, J. W., On a reciprocity condition for supersonic flutter, *J. Aero. Sci.* **24**, 12, p. 920, Dec. 1957; AMR **11**(1958), Rev. 5114.

31 Jogarao, C. V., and Lakshmikantham, C., Natural frequencies of rectangular plates with edges elastically restrained against rotation, *J. Aero. Sci.* **24**, no. 11, Nov. 1957.

32 Rodden, W. P., The flutter of two-dimensional flat panels with equally spaced supports in a supersonic flow, Ph.D. Thesis, Univ. Calif., Los Angeles, Oct. 1, 1957.

33 Miles, J. W., and Rodden, W. P., On the supersonic flutter of two-dimensional infinite panels, *J. Aero/Space Sci.* **26**, 3, p. 190, Mar. 1959.

34 Lin, C. C., Reissner, E., and Tsien, H. S., On two-dimensional non-steady motion of a slender body in a compressible fluid, *J. Math. Phys.* **27**, Oct. 1948.

35 Lock, M., The flutter of two-dimensional flat panels in the supersonic regime, Prog. Rep. 3, GALCIT 95, Contract AF 49(638)-220.

36 Shen, S. F., An approximate analysis of nonlinear flutter problems, *J. Aero/Space Sci.* **26**, 1, 25-32, Jan. 1959; AMR **12**(1959), Rev. 4160.

37 Miles, J. W., On panel flutter in the presence of a boundary layer, *J. Aero/Space Sci.* **26**, 2, 81-93, Feb. 1959; AMR **12**(1959), Rev. 4235.

38 Herrmann, G., and Mirksy, I., On vibration of conical shells, *J. Aero/Space Sci.* **25**, no. 7, July 1958; AMR **11**(1958), Rev. 1124.

39 Mushtarik, Kh., and Sachenkov, A. V., Stability of cylindrical and conical shells of circular cross section with simultaneous action of axial compression and external normal pressure, *NACA TM* 1433, Apr. 1958.

40 Kopzon, G. I., Vibration of thin-walled elastic bodies in a gas stream (in Russian), *Dokladi Akad. Nauk SSSR. (N.S.)* **107**, 2, 217-220, 1956; AMR **10**(1957), Rev. 33.

41 Movchan, A. A., On oscillation of a plate moving in gas (in Russian), *Prikl. Mat. Mekh.* **20**, 211-222, 1956.

42 Sponder, E., On the representation of the stability region in oscillation problems with the aid of the Hurwitz determinants, *NACA TM* 1348, Aug. 1952; AMR **6**(1953), Rev. 362.

43 Dugundji, J., A Nyquist approach to flutter, *J. Aero. Sci.* **19**, 6, 422-423, June 1952; AMR **6**(1953), Rev. 611.

44 Viktorov, I. A., Rayleigh-type waves on cylindrical surfaces (in Russian), *Akust. Zh.* **4**, 2, 131-136, 1958.

45 Kopzon, G. I., Vibrations of a shallow wing shell in a gas flow, *Dokladi Akad. Nauk SSSR (N.S.)* **107**, 3, 377-380, 1956; AMR **10**(1957), Rev. 34.

46 Stuart, J. T., and Woodgate, L., Experimental determination of aerodynamic damping on a vibrating circular cylinder, *Phil. Mag.* **46**, 40-46, Jan. 1955; Physics Abstracts **58**, no. 1604, Mar. 1955.

47 Iguchi, S., Eine Losung für die Berechnung der Biegsamen Rechteckigen Platten, Berlin, Julius Springer, 1933.

48 Arnold, R. N., and Warburton, G. B., Flexural vibrations of the walls of thin cylindrical shells having freely supported ends, *Proc. Roy. Soc. Lond. (A)* **197**, p. 238, 1949.

49 Arnold, R. N., and Warburton, G. B., The flexural vibrations of thin cylinders, *Proc. Instn. Mech. Engrs.* **167**, 62-74, 1953; AMR **7**(1954), Rev. 30.

50 Reissner, E., On transverse vibrations of thin shallow elastic shells, *Quart. Appl. Math.* **13**, 2, 169-176, July 1955; AMR **9**(1956), Rev. 1011.

51 Fung, Y. C., Sechler, E. E., and Kaplan, A., On the vibration of thin cylindrical shells under internal pressure, *J. Aero. Sci.* **24**, no. 9, Sept. 1957; AMR **11**(1958), Rev. 766.

52 Stanisic, M. M., An approximate method applied to the solution of the problem of vibrating rectangular plates, *J. Aero. Sci.*, Feb. 1957.

53 Bisplinghoff, R. L., Some structural and aeroelastic considerations of high speed flight, *J. Aero. Sci.* Apr. 1956; AMR **10**(1957), Rev. 109.

54 Hoff, N. J., Thermal buckling of supersonic wing panels, *J. Aero. Sci.* Nov. 1956; AMR **10**(1957), Rev. 691.

55 Kaul, R. K., and Tewari, S. G., On the bounds of eigenvalues of a clamped plate in tension, *J. Appl. Mech.* Mar. 1958; AMR **11**(1958), Rev. 1988.

56 Dryden, H. L., and Duberg, J. E., Aeroelastic effects of aerodynamic heating, AGARD Pub. AG 20/p 10, 102-107, June 1955; AMR **10**(1957), Rev. 3747.

57 Wittrick, W. H., Buckling of oblique plates with clamped edges under uniform compression, *Aero. Quart.* **4**, Feb. 1953.

58 Garner, H. C., and Acum, W. E., Problems in computation of aerodynamic loading on oscillating lifting surface, *Aero. Res. Counc. Lond. Curr. Pap.* 309, 1957; AMR **11**(1958), Rev. 595.

59 Miles, J. W., The aerodynamic force on an airfoil in a moving gust, *J. Aero. Sci.* Nov. 1956; AMR **10**(1957), Rev. 1153.

60 Miles, J. W., On harmonic motion at supersonic speeds, *J. Aero. Sci.* June 1949.

61 Miles, J. W., A first-order formulation of the unsteady supersonic flow problem for finite wing, *J. Aero. Sci.* June 1956; AMR **9**(1956), Rev. 3691.

62 Landahl, M., Unsteady flow around thin wings at high Mach numbers, OSR TN 55-245, June 1955; AMR **10**(1957), Rev. 2631.

63 Laidlaw, W. R., and Halfman, R. L., Experimental pressure distribution on oscillating low aspect ratio wings, *J. Aero. Sci.* Feb. 1956; AMR **9**(1956), Rev. 1918.

64 Lighthill, M. J., Oscillating airfoils at high Mach number, *J. Aero. Sci.* **20**, no. 6, June 1953; AMR **7**(1954), Rev. 250.

65 Milton, V. D., Supersonic flow past oscillating airfoils including nonlinear thickness effects, *NACA Rep.* 1183, 1954.

66 Zaratarian, G., Heller, A., and Ashley, H., Application of piston theory to certain elementary aeroelastic problems, Proc. Fourth Midwestern Conference on Fluid Mechanics, Purdue Univ. Sept. 1955, p. 163-181; AMR **10**(1957), Rev. 831.

# Analytical Methods in Applied Mechanics

(See also Revs. 19, 34, 35, 44, 48, 123, 156, 199, 286, 294, 327, 400, 404, 422, 486, 489)

**1. Proskuriakov, A. P., Investigation of the stability of the solution of a linear differential equation of the second order with periodic coefficients,** *Appl. Math. Mech. (Prikl. Math. Mekh.)* **22**, 2, 338-343, 1958. (Reprint order no. PMM 28, Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Author reviews previous papers concerning ground work for studying change of eigenvalues with respect to parameters. He developed the method by first describing the second-order linear equation with periodic coefficients in the form

$$\frac{d^2x}{d\varphi^2} + A\frac{dx}{d\varphi} + Bx = 0. \qquad [1.1]$$

Conditions are given which permit Eq. [1.1] to be reduced to Hill's type as follows:

$$\frac{d^2z}{d\varphi^2} + kz = 0. \qquad [1.2]$$

Next, the coefficient $K(\varphi, \mu)$ is defined by a series representation of the form

$$K(\varphi, \mu) = a + \sum_{n=1}^{\infty} [P_{on} + \sum_{m=1}^{\infty} (P_{mn} \cos m\varphi + Q_{mn} \sin m\varphi)]\mu^n \quad [1.3]$$

and the solution of Eq. [1.2] is presented as a series

$$z = e^{i\nu\varphi} \sum_{R=-\infty}^{\infty} H_k e^{ik\varphi}$$

An infinite determinant, elements of which depend on $a$, $P_{mn}$ and $Q_{mn}$ of [1.3] is used to determine $\nu$. This parameter in turn leads to the determination of the smallest eigenvalue of Eq. [1.1].

The last step in Proskuriakov's method is to define and develop conditions for the critical points. These conditions define the range of the determinant $D$ and lead to results of finding the maximum possible stability of the differential equation.

An application of the method is made to the differential equation which defines the motion of a propeller blade. The steps are:

(1) Reduce equation to Hill's type.

(2) Determine $D(\mu)$.

(3) Find smallest eigenvalue, $x = \frac{1}{8}\gamma - |I_m\nu|$.

(4) Examine critical points. Find maximum possible stability.

W. H. Sellers, USA

**2. Razumikhin, B. S., On the application of the Liapunov method of stability problems,** *Appl. Math. Mech. (Prikl. Math. Mekh.)* **22**, 3, 466-480, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Author considers the system

$$dn_i/dt = \sum_{j=1}^{n} p_{ij}(t)\, x_j \qquad [1]$$

where $p_{ij}(t)$ are given continuous bounded functions of time $t$, and $V$ a Lyapunov function, expressed by a positive definite quadratic form in $x_i$ with constant coefficients. He calls $L(V)$ the region of $n^2$ dimensional space of coefficients $p_{ij}$ where $dV/dt$ (calculated by [1]) is negative. He demonstrates that in $n^2$-dimensional space, $L(V)$ is bounded by a $n^2$-dimensional cone, in the $n$-dimensional space of coefficients of any equation of [1] (the coefficients of the other equation are supposed to be constant), $L(V)$ is bounded by an elliptic paraboloid, of which he derives some more properties. In particular he considers the system [1] equivalent to the equation

$$y^{(n)} + A_1^{(0)} y^{n-1} \dots A_{n-1}^{(0)} y^1 + A_n(t)\, y = 0 \qquad [2]$$

where $A_i^{(0)}$ are constant, $A_n(t)$ is a positive function of $t$, and obtains some sufficient conditions for the stability of the solutions of [2]. He even demonstrates that in the case $p_{ij}(t) = p_{ij}^{(0)} + t^{m_1} p_{ij}^{(1)} \dots t^{m_k} p_{ij}^{(k)}/p_{ij}^{(1)}$, $i, j = 1 \dots n$, $y = 1 \dots k$ constants, $0 < m_1 \dots m_k$ constants, the stability of obvious solution of [1] follows from the stability of obvious solution of the limiting system $dx_i/dt = \sum_{j=1}^{n} p_{ij}^{k} x_j$ and he exposes some conditions for the stability of nonlinear systems.

D. Graffi, Italy

**3. Shuleshko, P., A new method of solving boundary value problems of mathematical physics; Generalization of previous methods of solving boundary value problems of mathematical physics,** *Austral. J. Appl. Sci.* **10,** 1, 1–7, 8–16, Mar. 1959.

A procedure for solution of linear boundary-value problems is to select a complete set of functions, each fulfilling the boundary conditions (b.c.) and then determine a linear combination of these functions so that the differential equation (d.e.) is satisfied. An alternative procedure is the above statement with (b.c.) and (d.e.) interchanged. Present author only assumes set of functions is complete. In the first paper he introduces a convenient orthogonalization scheme and writes out the linear equation system which defines the connecting constants. The treatment includes as special cases the methods of Rayleigh-Ritz, Galerkin and others. Incidentally, it is known that for the Ritz method only completeness is required. See, for instance, "Approximate methods of higher analysis" by L. V. Kantorovich and V. I. Krylov, P. Noordhoff Ltd., Groningen, Netherlands, 1958, p. 258.

The second paper extends the range of the first paper by generalizing the orthogonalization process used there.

Only one example is given, and this in the first paper. It does not manifest utility of proposed procedures as the example is too ideal. Application to engineering problems is promised for subsequent papers.

Y. L. Luke, USA

**4. Shemiakin, E. I., On a method of integration of nonstationary linear boundary-value problems on the propagation of disturbances in non-ideally elastic media,** *Appl. Math. Mech.* (*Prikl. Math. Mekh.*) **22,** 3, 401–416, 1958. (Pergamon Press, 122 E. 55th St., New York 22, New York).

Equations of motion for the imperfect elastic media such as (1) Voigt model (viscoelastic medium), Newlands model (medium with dissipation, Boltzman model (medium with an elastic after effect) and Maxwell model (medium with relaxation) were deduced.

These equations are similar to those of perfect elastic media with the difference that the stress has the following form of expression $\sigma = ke + k\dot{e}$ where $k$ is an elastic constant, $\varepsilon$ is the strain and $K$ is some linear operator (differential operator for the cases (1) and (2) and integral operator for the others). In this case also the motion is separated into two independent quantities; one refers to $P$ waves and the other to $S$ waves.

Problems were presented which require the displacement vector operated by some linear operator involving above $K$ is equal to some function of space and time on the boundary surface $S$. Using Laplace transform the integral representation of the solution is given.

As the direct application of the theory the solution for the nonstationary problem for (1) viscoelastic half space, (2) half space occupied by a medium with an elastic after-effect are considered. The stress is either axisymmetric loading or non-symmetric tangential loading and is assumed to be concentrated around a point.

Comparison with the case of perfect elastical media is often done.

Y. Sato, Japan

**5. Muller, K., Exact solution of the Navier-Stokes differential equations for rotationally symmetrical flow** (in German), *Dtsch. Versuchsanstalt für Luftfahrt* no. 47, 53 pp., Dec. 1957.

A line source or sink coincides with the axis of rotation of a circular cone. The flow, for which the cone is a solid boundary, is determined as an exact solution of the Navier-Stokes equation. The rational solutions of the problem and the so-called jet flows are especially considered.

From author's summary by C. E. Carver, Jr., USA

**6. Trench, W. F., On an explicit method for the solution of a Stefan problem,** *J. Soc. Indust. Appl. Math.* **7,** 2, 184–204, June 1959.

Paper is concerned with numerical solution of a partial differential equation of parabolic type subject to a moving boundary condition. A simple physical interpretation involving heat conduction of a finite bar has been given by Evans, Isaacson and Macdonald ["Stefan-like problems," *Quart. Appl. Math.* **8,** 312–319, 1950]. Paper gives a review of previous work in this field. Author points out, for example, that Crank [AMR **11** (1958), Rev. 1365] has proposed a method of solution based on finite differences, but no proof of convergence was given. Present author develops an explicit finite difference analog. He proves convergence for all time and further that the convergence is uniform in every finite interval.

Y. L. Luke, USA

**7. Radok, J. R. M., and Wang, K., High order correct difference schemes for multi-dimensional parabolic equations,** AFOSR TN 59-329 (Polyt. Inst. Brooklyn, Dept. Aero. Engng. Appl. Mech. Rep. 492; ASTIA AD 213 676), 12 pp., Mar. 1959.

Compatibility conditions for explicit difference schemes for multidimensional parabolic equations have been established with the object of securing high-order truncation errors. A relationship between the coefficients of the multidimensional and the one-dimensional schemes has been deduced which provides a convenient means for their evaluation. The response of these high-order correct schemes to a particular mode of instability has been investigated. This mode, being a special case of the von Neumann criterion, is shown to lead, in the case of the classical schemes, to the well-known stability limits.

From authors' summary

**8. Lees, M., Approximate solutions of parabolic equations,** *J. Soc. Indust. Appl. Math.* **7,** 2, 167–183, June 1959.

Paper investigates convergence properties of several implicit finite difference analogs of a nonlinear parabolic equation. Uniform error estimates are derived. Procedures for numerical solution of nonlinear systems of equations are described.

Y. L. Luke, USA

**9. Bandyopadhyay, G., On certain lemma in connection with separable solutions of partial differential equations,** Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956, 269–270.

This note establishes that if the sum of three terms vanishes, each term being the product of functions of three independent variables, then two of the function sets must be proportional and the third set bounded by a linear relation.

From author's summary

**10. Siddiqi, O. A., On the solution of Fredholm integral equations of second kind,** Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 341–344.

Solution of integral equations of the second kind by expanding the unknown function $\phi(x)$ under the integral sign in a Maclaurin's expansion, integrating term by term, and evaluating the constants $\phi(0)$, $\phi'(0)$, etc., from consideration of the equations for $\phi(x)$, $\phi'(x)$, $\phi''(x)$, etc., is suggested. The general course of analysis is illustrated by detail of two particular examples. The suggested method yields approximate solutions agreeing with known approximate solutions obtained by classical procedures.

T. J. Higgins, USA

**11. Bolie, V. W., Minimum-storage matrix inversion** (in English), *ZAMM* **38,** 9/10, 369–372, Sept./Oct. 1958.

**12. Eisemann, K., Removal of ill-conditioning for matrices,** *Quart. Appl. Math.* **15,** 3, 225–230, Oct. 1957.

**Book—13. Graves, L. M., editor, Calculus of variations and its applications** (Proceedings of Symposia in Applied Mathematics, Vol. 8), New York, McGraw-Hill Book Co., Inc., 1958, v + 153 pp. $7.50.

This volume contains the papers presented to the Eighth Symposium in Applied Mathematics, sponsored by the American Mathematical Society and the Office of Ordnance Research, and devoted to the topic: The calculus of variations and its applications. The nine invited addresses are supplemented by invited comments by two speakers. The papers of most immediate concern to mechanical engineers are probably the following: On variational principles in elasticity, by Eric Reissner; Variational principles in the mathematical theory of plasticity, by D. C. Drucker; Stationary principles for forced vibrations in elasticity and electromagnetism, by J. L. Synge; A variational computation method for forced-vibration problems, by H. F. Weinberger; Variational methods in hydrodynamics, by S. Chandrasekhar. No short abstract can cover the diverse contents of these several papers. Each offers a brief exposition of some recent results, usually with a rich bibliography of reference material. Stationary and minimal values are explored but illustrate only the simplest topics in the formal theory of the calculus of variations.

A. A. Bennett, USA

**14. Langhaar, H. L., On the number of dimensionless variables in a problem of dimensional analysis,** *J. Appl. Mech.* **25,** 4, 622–623 (Brief Notes), Dec. 1958.

**15. Shvarts, Ya. A., The modelling of the process of extrusion of a clay mixture by a cement mixture when cementing vertical walls** (in Russian), *Izv. Akad. Nauk AzerbSSR* no. 10, 67–74, 1956; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4215.

The basic factors are enumerated which influence the process of extrusion of a clay mixture by a cement mixture; the $\pi$ theorem on similarity is used, the relevant criteria of similarity are brought in, and the question is discussed in regard to which of these criteria are material or realizable.

N. A. Slezkin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**16. Flanders, D. F., Product reliability measurement,** ASME Production Engng. Conf., Detroit, Mich., May 1959. Pap. 59-PROD-8, 8 pp.

This paper presents an approach to reliability measurement through the analysis of deficiency data feedback. Brief mention is made of the reporting documents, and the mechanics of the system. Several examples of operational problems are shown to indicate the scope of the product-improvement program. Failure rates by flying hours and durability curves are included in the examples discussed. The improvement in reliability is verified by reductions in problems and increased time between deficiencies.

From author's summary

**17. Klein, H., The experimental comparison of reduction in damage rates per unit time for jet engines,** Douglas Aircr. Co., Rep. SM-23419, 19 pp., Jan. 1959.

The problem of experimentally determining the average number of engine damages per unit time by observations of small samples is considered. Earlier work permitted estimation of confidence levels for a certain sample. The present report extends this to permit estimates of confidence level in the determined *ratio* of damage rates for an installation with protection as compared to one without protection.

From author's summary

**Book—18. Sansone, G., Orthogonal functions** (Pure and Applied Mathematics, Vol. 9), (Translated from the Italian by A. H. Diamond), New York, Interscience Publishers, Inc., 1959, xii + 411 pp. $11.

The book under review is an exposition of the classical theory of orthogonal series. The treatment is fairly extensive, detailed and rigorous. A wealth of information is packed between the covers of this book which should be useful to the worker in the applied fields. Unfortunately, a certain group of readers, namely, those lacking appropriate mathematical background, will find parts of the book not too easy to read. Analysis, which includes measure theory and the Lebesgue integral, are roughly prerequisites. However, everything possible is done to make the book self-contained. An excellent appendix helps in this matter.

As to content, the following chapter headings will give some indication: (I) Expansion in series of orthogonal functions and preliminary notions of Hilbert space, (II) Expansions in Fourier series, (III) Expansions in series of Legendre polynomials and spherical harmonics, and (IV) Expansions in Laguerre and Hermite series.

Professor Diamond's translation of Professor Sansone's treatise gives an excellent exposition of the subject of orthogonal functions, which is of fundamental importance in applied mathematics. It should be rewarding reading to the adequately prepared student, engineer or physicist.

E. J. Scott, USA

## Computing Methods and Computers

(See also Revs. 7, 30, 359)

**Book—19. Gelfond, A. O., Difference equations [Differenzenrechnung],** Berlin, VEB Deutscher Verlag der Wissenschaften, 1958, viii + 336 pp.

On first acquaintance with the calculus the Taylor series strikes one as a particularly ingenious discovery and at the same time poses the obvious question, in how many other ways may functions be approximated and which of these is most accurate or easiest to apply? Later, one meets Fourier series, Laurent series and many others, but a systematic discussion of the whole problem-complex is not ususally found in books on analysis. This void is filled by the book under review in a most competent and readable fashion.

The central theme is the expression of functions in terms of polynomials and series of diverse kinds. The treatment extends to analytical functions of a complex variable, thus departing from the conventional approach to finite difference calculus. With the methods so made available the classical problems of interpolation, construction of functions from given elements (e.g. from derivatives or moments, the latter as required in probability theory), summation of functions and difference equations are then treated in great depth. Also general periodic functions of a complex variable and

certain problems in number theory are discussed to illustrate the power of the methods evolved.

The book makes use of a good deal of relatively recent Russian work. However, it focuses on the complex variable and leaves out certain classical problems, such as the theory of numerical integration. The standard of the work is extremely high, following the tradition of this series of translations from the Russian. In spite of this, the requirements on the reader's background are quite modest; the theory of the gamma-function, e.g., is developed from the beginning. The mathematically minded engineer will undoubtedly follow the book through without difficulty and will certainly be richly rewarded for the effort.

L. C. Woods, England

**Book—20. Richtmyer, R. D., Difference methods for initial-value problems** (Interscience tracts in pure and applied mathematics, no. 4), New York, Interscience Publishers, Inc., 1957, xii + 238 pp. $6.50.

This book is a resume of the work on the numerical solution of parabolic and elliptic differential equations carried on at New York University over the past few years. Part I, entitled "General consideration," introduces the concept of stability by examining the solutions obtained on replacing

$$\frac{\partial u}{\partial t} = \sigma \frac{\partial^2 u}{\partial x^2} \quad \text{with } u(x,0) = \Phi(x) \text{ for } 0 \leqslant x \leqslant \pi, \quad u(0,t) = u(\pi,t) \text{ for } t \geqslant 0$$

by the difference form

$$\frac{u_j^{n+1} - u_j^n}{\Delta t} = \sigma \frac{u_{j+1}^n - 2u_j^n + u_{j-1}^n}{(\Delta x)^2}$$

and derives the stability condition

$$\frac{2\sigma \Delta t}{(\Delta x)^2} \leqslant 1$$

by insisting that the errors generated by unwanted components in the solution must die out. A brief chapter on linear operations in Banach spaces provides the technique for proving the basic theorem in the book, due to Peter Lax. In this, a properly posed initial-value problem and a consistent finite difference approximation are defined, along with concepts of stability and convergence, and it is shown that stability is necessary and sufficient for convergence. The theorem is applied to linear equations with constant coefficients to obtain stability conditions.

Part II, on "Applications," is the larger part and in a separate chapter for each, the equations for diffusion and heat flow, transport, sound waves, elastic vibrations, and fluid dynamics in one space variable are examined. In each case the physical significance of the terms in the equations is explained and the main techniques for solution are outlined. In many cases solutions obtained on UNIVAC for a range of parameters involved are given. Sometimes, equations not in the class for which the theory has been proved are discussed, e.g. nonlinear equations, or equations with varying coefficients, and it is seen that the general character of the results remains the same.

Altogether this is a satisfying book, one which is a pleasure to read, and a good example of the kind of work which is badly needed to bridge the gap often existing between computer programmers and pure mathematicians. A corresponding work on elliptic equations would be most welcome. C. C. Gotlieb, Canada

**21. Kreiss, H.-O., Approximative solutions of partial differential equations with the help of difference equations** (in Swedish), Trans. Roy. Inst. Technol., Stockholm, no. 128, 17 pp., 1958.

When difference equations are used to obtain approximate solutions to linear partial differential equations it is known that certain stability conditions on the difference equations are necessary. Also it has been shown that for well-posed initial-value problems stability is both necessary and sufficient. Author's problem is to determine under what conditions on the coefficients will stable, related difference equations exist.

A necessary and sufficient condition for stability of difference equations with constant coefficients is established. On the basis of this criterion for any well-posed initial-value problem with constant coefficients, a stable system of difference equations is designed.

From author's summary by B. Langefors, Sweden

**22. Coppel, W. A., The solution of cubic equations by iteration** (in English), *ZAMP* **9a**, 4, 380–383, Nov. 1958.

**23. Bukovics, E., Principles of the numerical solution of initial value problems for ordinary differential equations and methods of estimating the error** (in German), *Öst. Ing.-Arch.* **12**, 1/2, 66–82, Nov. 1958.

Well-organized, useful, general survey of the title subject, with good extensive bibliography, emphasizes the theoretical side of numerical solutions. No numerical examples are given. Paper is clearly written and recommended as introduction to engineers interested in the subject. T. Rivlin, USA

**24. Zajta, A., On iterative approximative methods, Part II** (in Hungarian), *Magyar Tud. Akad. Kem. Tod. Oszt. Közl.* **8**, 4, 457–472, 1958.

See AMR **11** (1958), Rev. 740.

**25. Holub, E., Triangular cross-section derivation of formulas** (in Czechoslovakian), *Stavebnicky Casopis* **5**, 3, 153–166, 1957.

**26. Radd, M. E., and Tek, M. R., Engineering applications of relaxation procedures by digital computation,** *AIChE J.* **5**, 1, 111–115, Mar. 1959.

The principle of the conventional method is briefly recalled: any elliptic differential equation of two independent variables can be replaced by a finite-difference equation; then the numerical solution of boundary-value problems can be rapidly obtained with the aid of an electronic computer. A block diagram of the digital relaxation routine is discussed. The main part of the paper is concerned with practical problems: pipe-flow velocity distribution, steady-state pressure in a reservoir, heat transfer in a tubular reactor. V. N. Baranov, France

**Book—27. Dreyer, G., Graphostatics—A textbook for engineering schools and for self study [Graphostatik—Lehrbuch für Ingenieurschulen und für den Selbstunterricht mit vielen Anwendungen auf Maschinenbau, Stahlhoch-und Bruckenbau],** Liepzig, Fachbuchverlag, 1957, vii + 254 pp. DM 12.50.

Short conventional treatment uses graphical and relatively simple analytical tools skillfully and thoroughly. Many excellent figures are included. Author scrupulously withholds the funicular polygon until halfway through the text, yet in an early application of the Cremona procedure, refers to need of the funicular polygon for best graphical treatment (page 52) and similarly on page 75.

Divisions are on the basis of theory: *A. Fixed loads* and *B. Moving loads.* Part A is divided into I. Equilibrium in plane forces. II. Application of the funicular polygon. In II, the classical basic Cremona, Culman and Ritter procedures are introduced, these being broadly concerned with the inner and outer local balancing of selected forces and moments. Three pages on statically indeterminate problems quickly admit them to be beyond the scope of the book. An extensive section on wind pressure, and related problems, with meticulous graphical and analytical solutions follows, augmented later with a treatment of positive and negative wind pressures, parallel forces, and other topics.

In III, Application of the funicular polygon, this tool is derived,

and its ability to help with centers of gravity, moments of inertia, continuous loading, turning and bending moments and use in the Culman procedure are thoroughly set forth.

Section B, Moving loads, includes treatment of the classical lines of influence.

Effective use is made of italics, light and very bold-face type, also of boxed tables, formulas and procedures. German style is simple and readable except for unusual words in the excellent practical problems worked and assigned. Use of the metric system is no drawback except for the comma in place of the decimal point. Analytical solution is often given in the former case, providing a satisfying check.

Startling finds are not expected in such ancestral territory but, as a short elementary book, this one is hard to beat for sheer thoroughness and workmanlike treatment of material.

D. P. Adams, USA

## Analogies

(See also Revs. 77, 412, 508)

**28. Matsunaga, S., A study of the adiabatic exponent of the "hydrodynamical gas" by statistical thermodynamics,** *J. Aero/Space Sci.* **26,** 8, 527–528 (Readers' Forum), Aug. 1959.

The fact that isentropic exponent of fictitious gas in shallow-water flow analogy to two-dimensional gas flow is $\gamma = 2$ is "explained" by author through observation that, for monatomic molecules restricted to plane motion (i.e., with only two degrees of freedom), statistical thermodynamics would indeed yield $\gamma = 2$.

J. V. Foa, USA

**29. Ishiguro, S., A method of analysis for long-wave phenomena in the ocean, using electronic network models, Part I: The earth's rotation ignored,** *Phil. Trans. Roy. Soc. Lond.* (*A*) **251,** 996, 303–340, Mar. 1959.

Method is applied to long waves in shallow waters. Familiar differential equations for tides, i.e. continuity and energy, are used, assuming no variation of atmospheric pressure, no wind shear stress, and friction proportional to first power of velocity. The latter assumption is warranted by the small importance of friction with respect to inertia. Hydraulic system is divided into a number of cells of constant depth. Cells are represented by a two-dimensional electric network formed by capacitors proportional to the area of the cell, variable inductors inversely proportional to depth of each cell and variable resistors proportional to the energy loss in each cell. Excitation is represented either by voltage (representing water surface elevation), or by electric current (representing total flow across each cell). Applications of method are given for a uniform-depth lake (one-dimensional and two-dimensional) with waves caused by a transient force and with steady oscillations; for a V-shaped bay disturbed by a pulse coming from the open sea and by stationary waves; for the oscillations characteristics of a lake (Lough Neagh), including transient oscillations due to a sudden wind affecting water levels two-dimensionally.

Satisfactory results are reported from comparison with actual observational data taken by Darbyshire and Darbyshire [*Quart. J. Roy. Meteor. Soc.* **83,** 355, 93–102, Jan. 1957]. Reviewer believes that method can be a good tool when analyzing tides and seiches with complex boundary conditions, specially when one-dimensional analysis is precluded. However, advantages of the analogy should be compared with respect to use of digital computers.

A. Balloffet, USA

**30. Merryman, J. D., and Clayton, W. H., A dynamic wind simulator for the frictional boundary layer,** *J. Meteorol.* **16,** 2, 155–166, Apr. 1959.

Paper describes an experimental model of an electronic analog computer which gives the wind velocity as a function of elevation, within the frictional boundary layer, at a single station on a plane over which no horizontal gradients of motion exist.

This is an experimental model designed only to demonstrate the superiority of analog over digital computers for this sort of research, but the authors plan to construct a simulator with many more refinements suitable for use as an operational forecasting unit.

The experimental model is described in detail and several solutions are illustrated by photographs of a cathode-ray oscilloscope.

R. W. Powell, USA

## Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 44, 262, 263, 475, 478)

**Book—31. Hannah, J., and Stephens, R. C., Mechanics of machines,** New York, St. Martin's Press, Inc., 1958, viii + 238 pp. $5.

This book includes 13 chapters referring to the usual main topics in mechanics of machines: dynamics; simple, harmonic motion; velocity and acceleration; valve diagrams; cams; crank effort diagrams; cams; crank effort diagrams; governors; balancing; friction; friction clutches; belt drives and band brakes; spur gearing; gear trains.

Each chapter includes, after a very concise theoretical introduction, many worked and unworked examples (in all, 106 worked and 291 unworked examples) with their final numerical solutions (in British units).

Almost all examples consist of problems set by London and Glasgow Universities, and by the Council of the Institution of Mechanical Engineers at their examinations.

Owing to their origin and their aim, they are, for the most part, excellent school examples, admitting simple, definite solutions.

Reviewer believes this book will be very useful to engineering students, for which it is intended, even if British units will probably restrict its circulation in European countries.

R. Giovannozzi, Italy

**32. Kel'zon, A. S., Equation for the motion of a point along a curved path with a constant angle of lead** (in Russian), *Uch. Zap. Leningr. Vyssh. Inzh. Morsk. Uch-shche* no. 5, 13–24, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6289.

A generalization is put forward of the classical problem regarding the trajectory for the case where the follow up is carried out with a constant angle of lead. For this case a qualitative analysis of the trajectory is made in a moving system of coordinates, linked up with the point being followed up. The time taken for the motion of the point being followed to reach its objective was determined.

E. N. Berezkin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**33. Radzievskii, V. V., and Gel'fgat, B. E., The delimited problem of two bodies of variable mass** (in Russian), *Astron. Zh.* **34,** 4, 581–587, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6283.

An investigation is carried out of the delimited problem of two bodies to cover the case where the mass $m$ of the central body changes in accordance with the principle $dm/dt = -\alpha m^n$. It is shown that with any arbitrary magnitude for the exponent $n$ the problem being investigated merges with the problem of two bodies with constant masses, moving under the action of their mutual gravitational pull, roused by quasi-elastic force and the force of friction. Some special cases were found of the integrational capacity of the differential equations for the motion of the material point.

M. I. Efimov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**Book—34. Malkin, J. G., Theory of stability of motion** [Theorie der Stabilitat einer Bewegung], München, R. Oldenbourg, 1959, xiii + 402 pp. DM 47.

This book offers an opportunity to the reader to close the gap between our Soviet colleagues and us in the field of nonlinear stability analysis. It considers equations of the form $dx_i/dt = F_i(x_j, t)$ under the condition that $F_i(0,t) \equiv 0$, where $x_j$ represents the difference between arbitrary solutions and a particular solution of a set of differential equations. The equilibrium solution is given by $x_i(t) \equiv 0$ and stability is associated with the possibility of finding a region about $x_i = 0$ such that all solutions starting in this region remain for all time as close to the equilibrium solution as one wishes.

The first part of the book treats stationary motion, i.e. $F_i$ does not contain the time explicitly. Analysis of the roots of the characteristic equations of the linearized form results in two cases. The critical cases are those in which the real part of all the roots is equal to or less than zero and at least one root has a real part equal to zero. Stability will depend entirely on the nonlinear terms in these cases, whereas in the noncritical case the linearized equations will determine stability; the region of stability being determined in both cases by the nonlinear terms. The question of stability and the region of stability are established by means of constructing Lyapunov functions, i.e., applying Lyapunov's second method.

The many examples offered are not nearly exhaustive; nevertheless, with some ingenuity one may use the book's technique and solve practically significant new problems. Therein lies the power of the book; besides giving recipes, it offers insight in constructing Lyapunov functions, a favorite pastime of Soviet engineers.

The second part treats nonstationary process; first assuming periodicity of $F_i$ as a function of time, later using general $F_i$. Again Lyapunov's second method is used and the analytical complications become somewhat demanding on the reader's background.

This book is strongly recommended in spite of the fact that it requires considerable labor and time-consuming devotion by the reader who desires to learn the technique.

This reviewer cannot recommend the English translation (Atomic Energy Commission, Translation #3352) for the polyglot.

A. M. Garofalo, USA

**35. Wang, C.-S., On the method of vectorial graphical computation of the forced vibration of the system with one degree of freedom** (in English), *Scientia Sinica* **8**, 2, 220–231, Feb. 1959.

Author presents a vectorial method for describing the forced vibration of a single-degree-of-freedom system similar to a method given by I. M. Rabinovich in 1954. The method is capable of deriving the vectorial diagram of the undamped (or damped) forced vibration for any given force distribution. Periodic and nonperiodic forces may be analyzed with intervening stretches of free vibration. The analytical procedure requires a differentiation of the force function and the integration of a set of linear differential equations of first order, and results in a parametric set (with the variable time) describing the vector diagram. While it is possible to analyze the displacement of a single-degree-of-freedom system by classical methods, author's procedure gives a physical picture of the motion involved and provides an assist if special characteristics (such as maximum displacement) are desired.

A. Rubio, USA

**36. Samuels, J. C., and Eringen, A. C., Response of a simply supported Timoshenko beam to a purely random Gaussian process,** *J. Appl. Mech.* **25**, 4, 496–500, Dec. 1958.

In a previous paper [AMR **11** (1958), Rev. 60] Eringen found that the mean square stress in a Bernoulli-Euler beam with transverse viscous damping subjected to white noise excitation was infinite. In this paper the problem is re-examined for a Timoshenko beam with both transverse viscous damping and rotary viscous damping. It is found that there is very little change in the mean square displacement, but now the mean square stress is finite and substantially constant over the length of the beam except very close to the ends.

A curious point is the inclusion of the word Gaussian in the title. There is no mention of it in the paper and the results obtained are certainly not restricted to Gaussian processes.

S. H. Crandall, USA

**37. Koronkevich, O. I., Resonance in linear dynamic systems under the action of random forces** (in Russian), *Nauchn. Zap. L'vovsk. In-ta* **44**, 184–194, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6315.

A system is examined consisting of differential equations of the first order with constant coefficients and free terms, representative of random forces. A case is investigated where, among the roots of the characteristic equation, some are found which are imaginary or of zero value.

M. E. Temchenko

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**38. Mitropol'skii, Yu. A., Nonstationary processes in nonlinear vibration systems** (in Russian), Kiev, Izd-vo Akad. Nauk USSR, 1955, 284 pp. + illus. 12r 55k; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5012.

Methods are systematically described for the investigation of nonstationary regimes in nonlinear vibration systems, having slowly changing parameters and the applications of these methods to a large number of examples. The method, based on the asymptotic methods of N. M. Krylov and N. N. Bogoliubov in nonlinear mechanics, is expanded to cover the processes which are described by a system of differential equations having the form of

$$\frac{d}{dt}\left\{\sum_{i=1}^{N} a_{ij}(\tau)q_i\right\} + \sum_{i=1}^{N} b_{ij}(\tau)q_i = \varepsilon Q(\tau, \theta; q_1, \ldots, q_N; \dot{q}_1, \ldots, \dot{q}_N, \varepsilon) \quad (j = 1, \ldots, N) \quad [1]$$

$$\frac{d}{dt}\left\{\sum_{i=1}^{N} a_{ij}(\tau)\dot{q}_i\right\} + \sum_{i=1}^{N} c_{ij}(\tau)\dot{q}_i + \sum_{i=1}^{N} b_{ij}(\tau)q_i = \varepsilon Q(\tau, \theta; q_1, \ldots, q_N; \dot{q}_1, \ldots, \dot{q}_N; \varepsilon) \quad [2]$$

where $\varepsilon$ is the small parameter, $\tau = \varepsilon t$ is the "slow time," the right hand parts relative to $\theta$ are periodic functions with a period of $2\pi$. It is assumed here that coefficients $a_{ij}$, $b_{ij}$, $c_{ij}$, ($a_{ij}(\tau) = a_{ji}(\tau)$, $b_{ij}(\tau) = b_{ji}(\tau)$, $c_{ij}(\tau) = -c_{ij}(\tau)$) and magnitude $\nu(\tau) = d\theta/dt$ ($\nu(\tau) \geqslant 0$) slowly changes with time and that on any end segment $0 \leqslant \tau \leqslant \Omega$ the quadratic forms

$$T = \frac{1}{2}\sum_{i,j=1}^{N} a_{ij}(\tau)\dot{q}_i\dot{q}_j, \qquad V = \frac{1}{2}\sum_{i,j=1}^{N} b_{ij}(\tau)q_iq_j$$

are positively determined, while functions $a_{ij}(\tau)$, $b_{ij}(\tau)$, $c_{ij}(\tau)$, $\nu(\tau)$, $Q_j(\tau, \theta; q_1, \ldots, q_N; \dot{q}_1, \ldots, \dot{q}_N, \varepsilon)$ are capable of differentiation without limit at all values of their arguments, $\tau$, $\theta$, $q_1, \ldots, q_N$; $\dot{q}_1, \ldots, \dot{q}_N$ and at sufficiently small $|\varepsilon|$. Equations [2] differ from [1] because of the presence of the gyroscopic terms $c_{ij}(\tau)\dot{q}_i$. A scheme is worked out for the systems of Eqs. [1] and [2] for the derivation of approximate solutions in the form of asymptotic series, when, together with the solutions corresponding to a single frequency regime in a vibration system, a general solution is derived as well. One of the four chapters of the monograph is devoted to systems with one step of freedom ($N = 1$). An examination

is made, in the shape of examples of the application of the method, of: the passage through resonance in a nonlinear vibrator, under the action of an external sinusoidal force of variable frequency, the oscillations of a pendulum with a variable length, a nonstationary regime with emergence of fractional resonance, the reaction of a nonlinear vibration system of an exciting force with several harmonics, the torsional vibrations of a roller, carrying on its ends masses varying with time, and so forth. The author brings under scrutiny the following, as examples of the application of the method to vibration systems possessing several steps of freedom: the passage through resonance of a gyroscopic system in the nature of a centrifuge, the transition of the crankshaft of an aero engine from one regime of work to another, the motion of a load jointly with a pulsating force along a beam, etc. The mathematical substantiation of the method forms the subject matter of the last chapter. In that chapter are examined: the asymptotic convergence of the approximate solutions, an evaluation of the extent of error of the approximation, and also some criteria of stability of the single frequency regime in vibration systems. The book is designed for use by engineers and scientific workers and also for alumni and students in the advanced courses of the technical institutions.

I. M. Volk

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**39. Kaliski, S., Some boundary-value problems of the dynamic theory of elasticity and inelastic solids** (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7**, 159–174.

Paper presents methods for the mathematical analysis of free vibrations and forced vibrations of elastic and inelastic solids. The first part of the paper discusses the use of a dynamic function of displacement of an elastic, homogeneous, anisotropic solid; also dynamic functions for orthotropic, transversely isotropic, and isotropic solids in Cartesian and cylindrical coordinates. By the use of these dynamic functions of displacement and the method of the separation of variables, eigenvalues and eigenfunctions are determined for certain special boundary-value problems. The case of a rectangular parallelepiped with certain boundary conditions is discussed in some detail.

In the second part, it is assumed that the eigenfunctions and eigenvalues of the dynamic boundary-value problem are known, and general solutions are obtained for nonstationary and thermal vibrations. The vibrations of inelastic solids are discussed by the construction of linear models. The models of Voigt, Maxwell and Boltzman are discussed. The nonlinear model proposed by Sorokin is also considered. The Laplace transform method is used in the discussion of the Boltzman model. By the use of this technique an "operator function of displacements" is obtained. This procedure reduces the dynamic problem to an equivalent static problem. By the inversion of the Laplace transforms obtained, the ultimate solution of the dynamic case is obtained.

In the opinion of the reviewer this paper presents a novel approach to vibration problems of solids. Because of space limitations, the treatment is quite terse but the specialist in this field will find the paper very valuable and suggestive of possible applications of the methods presented to complex special cases.

L. A. Pipes, USA

**40. Gates, O. B., and Minka, K., Note on a criterion for severity of roll-induced instability,** *J. Aero/Space Sci.* **26**, 5, 287–290, May 1959.

Divergence rates are estimated from equations based on assumed steady-state rolling velocities. The severity of the pitch yaw coupling instability is a strong function of these rates of divergence. From the rates, the divergence as a function of bank angle can also be estimated, and can occur initially in either pitch or yaw mode, depending on the relative natural frequencies in each one.

H. P. Liepman, USA

**41. Lykova, O. B., Single-frequency vibrations in systems with slowly changing parameters** (in Russian), *Ukrain. Mat. Zb.* **9**, 2, 155–162, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6314.

An examination is made of a system of equations

$$\frac{dx}{dt} = X(\tau,x) + \varepsilon X^*(\tau,\theta,x,\varepsilon) \qquad [1]$$

in which $x, X, X^*$ are $n$-dimensional vectors, $\varepsilon$ is the small positive parameter

$$\tau = \varepsilon t, \qquad \tau\varepsilon[0,L], \qquad \frac{d\theta}{dt} = \nu(\tau) > 0$$

Assumptions are introduced: (a) For the system of undisturbed equations with constants $\tau\varepsilon[0,L]$ ($L$ being as large as required for an $\varepsilon$ as small as required) a family of periodic solutions is available

$$x = x^0(\tau,\ w t + \varphi, a) \qquad [2]$$

where $\varphi, a$ are constants, $\tau$ the parameter, $w = w(\tau,a)$. (b) For the system of equations with variations, derived for solution [2], with arbitrary values for $\tau\varepsilon[0,L]$ two characteristic exponents equal to zero shall have negative real parts (on the strength of the supposition of the existence of a two-parameter family of periodic solutions). (c) Functions $X(\tau,x) + \varepsilon X^*(\tau,\theta,x,\varepsilon)$ are periodic in regard to $\theta$ with a period of $2\pi$ and capable of integration to infinity with $x,\tau,\varepsilon$ in the region $\tau\varepsilon[0,L]$, $\theta\varepsilon\Omega$, $x\varepsilon U_\rho$, $0 < \varepsilon < \varepsilon_*$, where $U_\rho - \rho$ is the vicinity of the family of closed orbits in an $n$-dimensional space. An approximate two-parameter family of special solutions of system [1] is derived for $t\varepsilon[0,L/\varepsilon]$ which are close to the family of solutions [2] as regards orbit, provided the values for $\varepsilon$ are sufficiently small.

M. E. Temchenko

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**42. Soper, W. G., Transient response of accelerometers,** *Proc. Soc. Exp. Stress Anal.* **16**, 1, 187–190, 1958.

Author considers response of simple seismic system to accelerations varying linearly with time. He shows how to compute discrepancy between accelerometer output and acceleration measured provided oscillations of seismic mass are damped rapidly compared to duration of acceleration step. Successive linear acceleration steps are treated. Calculation is simple and straightforward.

E. G. Chilton, USA

## Instrumentation and Automatic Control

(See also Revs. 359, 446)

**Book—43. Murphy, G. J., Control engineering,** Princeton, N. J., D. Van Nostrand Co., Inc., 1959, xii + 385 pp. $7.50.

The objective of the author has been to present an up-to-date textbook at the junior or senior level for a reader with an elementary background in differential equations, electric circuit theory and mechanics. He has succeeded in covering the usual background material such as the Laplace transform, transfer functions, stability, frequency response, and carrier systems in a readable concise manner. In addition the treatment of the newer topics, systems with dead time, sampled-data systems, and noise in control systems is an excellent introduction for the better-prepared undergraduate student or the beginning graduate student. The book closes with a brief introduction to phase plane methods and mention of some nonlinear problems. There are numerous examples and problems chosen from many fields as well as copious references. The typography and figures are excellent.

E. Saibel, USA

**Book—44. Wiener, N., Nonlinear problems in random theory,** New York, John Wiley & Sons, Inc., 1958, ix + 131 pp. $4.50.

This book is composed of a set of fifteen lectures given by the author on nonlinear statistical theory. The author was inspired to develop this theory by a desire to explain a dip in the power density spectra of electroencephalogram voltages obtained in brain-wave experiments. The concept of impedance, characterizing the response of linear systems to sine wave inputs, is inadequate for nonlinear systems. Author shows that, whereas the response of a linear system to essentially any input is determined by its response to sinusoidal inputs, the response of a nonlinear system to essentially any input is determined by its response to a Brownian motion or shot-effect input. The theory involves the use of Laguerre and Hermite expressions in terms of which the author develops the analysis and synthesis of nonlinear systems, and in particular the mathematical characterization of nonlinear black boxes. He applies his approach to quantum mechanics, coding, decoding, and statistical mechanics. In reviewer's opinion the book will appeal to both the mathematically minded control and communications expert, and to the physicist concerned with dynamic phenomena. R. Oldenburger, USA

**45. Merriam, C. W., III, A class of optimum control systems,** *J. Franklin Inst.* **267,** 4, 267–281, Apr. 1959.

The control performance of a system is measured by the integral of properly weighted deviations of the actual input and output from their desired values. The integration is performed from the time of measurement of the actual state of the system to a later time. The input and output are described by a state variable and its derivatives. In order to obtain the optimalizing function of the manipulated variable, the dynamic programming formalism of the calculus of variations is applied in minimizing the integral error. The explicit form of the solution is examined for linear processes and quadratic error. Furthermore, the solution is required to be of such a nature that the minimum condition is satisfied regardless of the state of the process. The synthesized controller consists of a forward part, termed *director portion*, and a feedback part, called *feedback portion*. If limitations are imposed upon the value of the optimalizing function, a third term, called switching portion, is present in the expression for the optimal manipulated variable. The coefficients of the synthesized controller are independent of the states of the process. The coefficients of the director portion are time-variable and linearly dependent on the desired behavior of the system, while the coefficients of the feedback portion do not depend upon the desired behavior.

The resulting controller is termed adaptive because optimization can be performed continuously with respect to the actual state of the system and further is called separable because the feedback portion has the task of adaptation and the director portion has the task of controlling the behavior of the process with respect to the desired behavior. The mean-square prediction for the random input and a separable class of systems is performed.

M. Mesarovic, USA

**46. Follinger, O., The determination of the root loci** (in German), *Regelungstech.* **6,** 12, 442–446, Dec. 1958.

The application of the root-locus method can be simplified if the equation of the locus in the complex domain is known. To this end, the general rules for the analytical representation of the root loci have been given. From the equations of loci, general properties can be deduced without plotting the graphs; consequently, the eventual graphical representation can be obtained more rapidly. The advantages of using the analytical representation of the loci have been demonstrated by some practical examples.

M. Mesarovic, USA

**47. Ogata, K., Subharmonic oscillations of nonlinear feedback control systems,** *Trans. ASME* **80,** 8, 1802–1808, Nov. 1958.

See AMR **12** (1959), Rev. 1705.

**48. Gibson, J. E., Nonlinear systems design. Part I. How to construct a phase plane plot,** *Control Engng.* **5,** 10, 69–75, Oct. 1958.

**49. Banerjee, H., and Bhattacharyya, B., Determination of the error coefficient of a stable, unity feedback, linear servomechanism and its error response for arbitrary forcing functions,** *J. Technol., India* **3,** 1, 1–12, June 1958.

Authors present a graphical method to obtain the various error coefficients of servo systems by plotting the overall Green's functions of the system. Graphical representation facilitates the evaluation of errors of systems whose input function cannot be represented as mathematical function of time.

Example shows the synthesis of an instrument servomechanism based on a graphically represented nonlinear displacement-versus-time input. P. P. Biringer, Canada

**50. Pugachev, V. S., General theory of random functions and its application to the theory of automatic control** (in Russian), Trans. All-Soviet conference on the theory of automatic control **2,** Moscow-Leningrad, Izd.-vo Akad. Nauk SSSR, 1955, 403–424; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6330.

This report-review, based in the main on matter published previously by the author [*Izv. Akad. Nauk SSSR. Ser. Matem.* **17,** 5, 401–420, 1953] and others has many points of contact with the succeeding monograph ["Theory of random functions and its application to the problems of automatic control," Moscow, Gostekhizdat, 1957]. The review is divided into the following parts: 1. Moments of random functions (determination and characteristic properties of moments of different orders, the stationary state in its narrow and wide sense). 2. Theory of the canonical resolution of random functions (different forms of canonical resolutions, including the spectral resolution to meet the case of stationary functions). 3. Vector random functions (determination of and canonical resolutions for such functions). 4. Theory of the linear conversions of random functions (formulas for the moments and the canonical resolutions of the random function, obtained from the initial random function with known moments and known canonical resolution by the use of linear conversion). 5. Theory of nonlinear conversions of random functions (some results relating to the moments and canonical resolutions of the random function obtained with the aid of nonlinear conversion). 6. Statistical investigation of the random system (application of the theory of linear conversions of random functions to the linear conversions, realized by linear systems of automatic control). 7. Approximate statistical investigation of nonlinear systems by the method of linearization (application of the method of canonical resolutions to systems, recorded by means of nonlinear equations with subsequent linearization). 8. Statistical investigation of nonlinear systems (application of methods in Part 5 to nonlinear systems of automatic control). 9. Problems relating to the synthesis of systems of automatic control (a short review of investigations in this field). 10. Prospects for the extension of statistical methods in the theory of automatic control (the listing of a series of problems requiring further researches). A. M. Yaglom

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**51. Tsypkin, Ya. Z., and Gol'denberg, L. M., Derivation of the transition process in systems of automatic control by means of the characteristics of their individual linkages** (in Russian), *Trudi Vses. Zaochn. Energ. In-ta* no. 7, 90–106, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 4992.

Questions are examined relating to the approximate solution of the time characteristics of closed linear systems, by using the transmission functions or the time characteristics of the links of these systems. In conformity with the known formula in the theory

of impulse systems, control is achieved of the transition from a continuous transmission function to a discrete transmission function. The bond between the discrete values of the end and starting magnitudes of the continuous system is recorded in the form of a sum (the discrete weight function). The coefficients of the weight of this sum are equal to the coefficients of the resolution into a series of the discrete transmission function of the closed system. No explanation is given to the effect that the formula given to link up the discrete values of the starting and end magnitudes is actually a precise one, but nevertheless requires the finding of the poles of the transmission function of the closed system. The approximate formula is obtained by replacing the precise discrete transmission function with functions composed of the coefficients of transmission of the individual links. This formula does not require a solution for the characteristic equation of the closed system. The most simple examples are furnished to show the application of the method. Some variants of the method are demonstrated; for example, for the calculations of undirected chains and to cover the case of an approximate determination of a discrete transmission function by means of substitution of an independent parameter. The work contains references of previously published studies dealing with this question.

A. A. Krasovskii
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**52. Ostrovskii, G. M., Application of nonlinear arrangements in systems of automatic control of the third order** (in Russian), Vestn. Mosk. In-ta no. 1, 51–56, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 4995.

The problem is studied of the determination of the form of functions $f_1(x)$ and $f_2(x)$ for which the system of automatic control described by the equation

$$\dddot{x} + f_1(x)\ddot{x} + f_2(x)\dot{x} + x = 0 \qquad [1]$$

shall be optimal, in the sense that the transition process evoked by the single impulse in the system shall not be overcontrolled, while the time-lapse in the course of which the error becomes less than the assigned determined magnitude shall have its minimum value. It is shown that these functions should have the form

$$f_1(x) = \begin{cases} a_1 \text{ where } \Phi(x, \dot{x}, \ddot{x}) < 0 \\ b_1 \text{ where } \Phi(x, \dot{x}, \ddot{x}) \geqslant 0 \end{cases}$$

$$f_2(x) = \begin{cases} a_2 \text{ where } \Phi(x, \dot{x}, \ddot{x}) < 0 \\ b_2 \text{ where } \Phi(x, \dot{x}, \ddot{x}) \geqslant 0 \end{cases}$$

while $a_1 \leqslant f_1(x) \leqslant b_1$, $a_2 \leqslant f_2(x) \leqslant b_2$, where $a_1$, $a_2$, $b_1$, $b_2$ are constants. When $f_1(x) = a_1$ and $f_2(x) = a_2$ the system finds itself on the border of stability and the characteristic equation has two imaginary roots. When $f_1(x) = b_1$, $f_2(x) = b_2$ the system is strongly damped and the characteristic equation has three actual roots $-\gamma_1 > -\gamma_2 > -\gamma_3$. Function $\Phi(x, \dot{x}, \ddot{x})$ has the form

$$\Phi(x, \dot{x}, \ddot{x}) = [\ddot{x} + (\gamma_2 + \gamma_3)\dot{x} + \gamma_2\gamma_3 x]\dot{x} \qquad [2]$$

In order to give substance to the system a recommendation is made to add to it a calculation-solving factor to solve Eq. [2] and to react on the relay by a jump, changing the parameters of the system, when function $\Phi(x, \dot{x}, \ddot{x})$ passes over to a zero value.

A. A. Voronov
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**53. Levitan, S. A., and Kaganov, V. Yu., An electromechanical model of a thermal project for investigation of systems of automatic regulation** (in Russian), *Trudl Mosk. Energ. In-ta* no. 18, 309–319, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 141.

A scheme and principle of operation is given of a model of a thermal project. To construct a scheme of a model representing some thermal object, its time function is substituted by an approximation composed of two exponentials and a time lag. The model is constructed from two inertia links connected in series (on input and output) and from a retarding link. A regulator connected to such a model is investigated. All transient processes in the system of an automatic regulation are recorded by potentiometer and an analysis of these results enables one to introduce some corrections and to choose parameters of the regulator.

A. M. Egorov
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**54. Pian, T. H. H., and O'Brien, T. F., Transient responses of continuous structures using assumed time functions** (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7**, 350–359.

A new approach for transient solutions of continuous elastic structures is suggested. Approximate time histories for the structural response are assumed over a short time interval and the differential equations for the mean normalized spatial distribution are found by the application of Hamilton's principle. Using single-term approximations to the time history, numerical examples have been carried out in the case of a uniform cantilever beam under a concentrated tip load having the form of a step function. From authors' summary by H. J. Plass, USA

**55. Cawood, W., Some design problems in inertia navigation,** *J. Roy. Aero. Soc.* **62**, 574, 704–722, Oct. 1958.

**56. Gibson, W. E., Three axis flight simulator systems,** *Aero/Space Engng.* **17**, 8, 36–39, 44, Aug. 1958.

**57. Sitnitzky, J. I., Investigation of velocity thermocouple as corrective link in automatic control system for superheated steam** (in Russian), *Teploenergetika* no. 9, 30–33, 1958.

From frequency characteristic of the differential equation for the velocity thermocouple it is shown that the thermocouple acts as a differential link only for certain values of time-constant parameters. Recommendations are given for selection of optimum values of parameters for a velocity-sensitive thermocouple acting as a correcting link. Experimental techniques are presented for determining time constants for thermocouples. A velocity-sensitive thermocouple is made up of a junction of two thermo-elements with identical characteristics. The active elements of this junction possess heat resistance (author's term was "heat inertness"). Electromotive force initiated by such a thermocouple is assumed by author to be approximately proportional to velocity of temperature variation.

Velocity-sensitive thermocouple can be pictured as a cross-parallel junction of two aperiodic working junctions known as links. In solving this problem, author employed theoretical and experimental techniques. In conclusion, author states that practicability of proposed method was verified experimentally.

V. A. Valey, USA

**58. Goodman, L. E., and Robinson, A. R., Thermal drift of floated gyroscopes,** *J. Appl. Mech.* **24**, 4, 506–508, Dec. 1957.
See AMR **11** (1958), Rev. 2430.

## Elasticity

(See also Revs. 4, 39, 90, 97, 123, 164, 170, 171, 176, 177, 202)

**Book—59. Budyka, I. I., Calculations for the strength of disks of steam turbines** (in Russian), Moscow-Leningrad, Mashgiz, 1956, 151 pp. + illus., 3r., 95k.; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7144.

Book deals with the calculations for disks of steam turbines in regard to their strength during elastic deformations. The basic

equations are given for the equilibrium of the disks of arbitrary profile and constant thickness. Methods are investigated for the calculations of disks of constant thickness, of conical or composite conical profiles, of arbitrary profile, of hyperbolic profile and of disks of equal resistance. The calculation for the rim of the disk is examined, as also the determination of the radial stress in the body of the disk at the point of the stress transition to the rim, and the determination of the disk weight. Examples are given of the calculations for disks of various profiles.

K. S. Pul'kis

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**Book—60. Gol'denblat, I. I., Some questions regarding the mechanics of deforming media** (in Russian), Moscow, Gostekhizdat, 1955, 272 pp., illus. 9r 55k; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5806.

The book has two parts. The first part, consisting of seven chapters, deals with the general forms of linkage between fields of stresses and deformations. A preliminary survey is carried out of the invariants of fields of deformations, stresses, velocities of deformation and stresses and also of the joint invariants of these fields. The basic invariants are filled by: three algebraical invariants of the stress tensor

$$\Pi_1 = g_{\alpha\beta}\sigma^{\alpha\beta}, \quad \Pi_2 = \sigma_{\alpha\beta}\sigma^{\alpha\beta}, \quad \Pi_3 = \sigma_{\alpha\beta}\sigma^{\beta}_{\gamma}\sigma^{\gamma\alpha}$$

three algebraical invariants of the deformation tensor

$$I_1 = g_{\alpha\beta}\varepsilon^{\alpha\beta}, \quad I_2 = \varepsilon_{\alpha\beta}\varepsilon^{\alpha\beta}, \quad I_3 = \varepsilon_{\alpha\beta}\varepsilon^{\beta}_{\gamma}\varepsilon^{\gamma\alpha}$$

and the invariants of the tensors of velocities of stress and deformation

$$R_1 = g_{\alpha\beta}\dot{\sigma}^{\alpha\beta}, \quad R_2 = \dot{\sigma}_{\alpha\beta}\dot{\sigma}^{\alpha\beta}, \quad R_3 = \dot{\sigma}_{\alpha\beta}\dot{\sigma}^{\alpha}_{\beta}\dot{\sigma}^{\beta\gamma}$$
$$S_2 = \dot{\varepsilon}_{\alpha\beta}\dot{\varepsilon}^{\alpha\beta}, \quad S_3 = \dot{\varepsilon}_{\alpha\beta}\dot{\varepsilon}^{\beta}_{\gamma}\dot{\varepsilon}^{\gamma\alpha}, \quad S_1 = g_{\alpha\beta}\dot{\varepsilon}^{\alpha\beta}$$

recorded in tensor notation. These questions take up three chapters. In the fourth chapter an examination is made of the forms of linkage between the components of the tensors of stresses and deformations to cover the cases of deformations in equilibrium of isotropic media. It was established that when studying the generally possible forms of linkage between fields of stresses and small deformations it was most convenient to make use of the basic invariants $\Pi_1$, $\Pi_2$ and $I_1$ and $I_2$.

The linkages between the stresses and deformations become known when two independent invariants of the tensor of stresses are assigned as functions of two independent invariants of the tensor of deformation and an absolute temperature. As examples one might select $\Pi_1 = \Pi_1(I_1, I_2)$, $T_2 = T_2(I_1, I_2)$. In the case of finite deformations the linkage between the components of the tensor stresses and the tensor of deformation is determinable fully by assigning three invariant equations of the nature $\Pi_1 = \Pi_1(I_1, I_2, I_3)$ $T_2 = T_2(I_1, I_2, I_3)$, $T_3 = T_3(I_1, I_2, I_3)$, linking three invariants $\Pi_1$, $T_2$ and $T_3$ with three invariants of the tensor of deformations $I_1$, $I_2$, $I_3$ and the absolute temperature $T$. In the fifth chapter an investigation is carried out of the general forms of linkage between the fields of stresses and deformations for unbalanced processes of deformation of isotropic media. Here the linkages between the components of the tensor of stresses and the tensor of velocities of deformations are determinable fully by assigning three invariant equations to link up three basic invariants of the tensor of stresses $\Pi_1$, $\Pi_2$ and $\Pi_3$ with three basic invariants of the tensor of velocities of deformations $S_1$, $S_2$ and $S_3$. The sixth chapter contains the results of extending to anisotropic media some of the relationships obtained in the fourth chapter. Thus, the linkages between $\sigma_{ik}$ and $\varepsilon_{ik}$ become determinable in full by assigning the tensor of anisotropy $A_{ikrs}$ and the invariant equations

$$\Pi_1 = \Pi_1(\overset{*}{I}_1, \overset{*}{I}_2), \quad T_2 = T_2(\overset{*}{I}_1, \overset{*}{I}_2), \quad \overset{*}{I}_1 = A_{ikrs}\varepsilon_{rs}\delta_{ik}$$

$$\overset{*}{I}_2 = A_{ikrs}\varepsilon_{ik}\varepsilon_{rs}$$

The seventh chapter deals with the linkage between the direction of the principal axes of the tensor of stresses and deformation for balanced and unbalanced processes of deformation of isotropic media.

The second part of the book, also consisting of seven chapters, is devoted to the application of the basic principles of thermodynamics to the processes of small and arbitrary finite deformations of isotropic and anisotropic media. An exposition of the first and second beginning of thermodynamics is given in the eighth chapter; this is based on the theory of invariants. The ninth chapter deals with the thermodynamic potentials of deformation in the invariant form. An analysis of the differential equations for the invariants of the tensors of stresses and deformations and for the thermodynamic potentials forms the main subject of Chapter X. An examination of Koshi's problem for the differential equations for thermodynamics is also made. Some questions on the thermodynamics of anisotropic media are discussed in Chapter XI. Thermodynamic potentials are investigated and the basic equations for the state are recorded. In Chapter XII deformations of elastic-viscous media are investigated, when in a variable field of temperature; the differential equations for the kinetics of the phase transformations are derived. The thirteenth chapter deals with the thermodynamics of arbitrary end deformations. In this chapter are given the derivation and analyses of the basic equations for the condition in invariant form. By way of illustration the results obtained are applied to the analysis of the deformation of caoutchouc. The fourteenth chapter is devoted to the problem, in its general terms, of the motion of an unbroken sphere, disregarding its divergence from thermodynamic equilibrium, viscosity and thermal capacity.

M. I. Rozovskii

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**61. Sobolev, V. Kh., Solutions of the three-dimensional equation of theory of elasticity in dislocations** (in Russian), Trudi Nauch. Konferentsii Stalinskogo Ped. In-ta no. 1, Kemerovsk. Kn. Izd-vo., 1956, 280–291; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 944.

Solutions of equations of elasticity in dislocations are expressed by three harmonic functions which are written in the form of sum of products of hyperbolical function of one variable coordinate and function of two remaining coordinates.

M. G. Slobodyanskii

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**62. Adkins, J. E., A three-dimensional problem for highly elastic materials subject to constraints,** *Quart. J. Mech. Appl. Mech.* **11**, 1, 88–97, Feb. 1958.

**63. Tolokonnikov, L. A., Plane deformation of incompressible material,** *Soviet Phys.-Doklady* **3**, 2, 453–456, Dec. 1958. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **119**, 6, 1124–1126, Mar.-Apr. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

The nonlinear theory of elasticity for the case of plane deformations is considered. The differential equation of the stress function is obtained. For solutions of specific problems it is possible to employ Muskhelishvili's method. The magnitudes of strains and displacements are not limited.

Z. Olesiak, Poland

**64. Stippes, M., A half-infinite plate with an elastically restrained edge** (in English), *ZAMM* **38**, 9/10, 401–402, Sept./Oct. 1958.

**65. Verma, P. D. S., Deformation energy for hypo-elastic materials of grade zero** (in English), *J. Sci. Engng. Res., India* **2**, 2, 251–252, July 1958.

Author shows that, for hypoelastic bodies of grade zero, the internal energy is the same function of the stress as it is in linear elasticity theory. J. L. Ericksen, USA

**66. Valov, G. M., Problem of the equilibrium of a rectangle in mixed boundary conditions** (in Russian), Investigations on the theory of constructions no. 7, Moscow, Gosstroiizdat, 1957, 401–411; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6940.

Two cases are investigated dealing with the plane problem in the theory of elasticity for a rectangle with mixed boundary conditions when these conditions are symmetrically assigned relative to the axes of symmetry of the rectangle. In the first problem, normal stresses are given to two parallel edges of the rectangle and also changes of position along these edges, the other edges being free from loading. In the second problem, changes of position are assigned to two parallel edges, the other edges again remaining free from loading. The problems were solved by Fourier's method. In the first problem the integration constants are determined directly. As a numerical example the problem is examined of the compression of a square by an uniform load. In the second problem the determination of the integration constants merges with the solution of infinite systems of linear equations. No numerical example is given for this case. The paper makes no mention of the work of V. K. Prokopov [*Prikl. Mat. Mekh.* **16**, no. 1, 1952] who investigated the plane problem of a rectangular strip on whose transverse edges there were no normal changes of position.

B. L. Abramyan

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**67. Babich, V. M., The S. L. Sobolev-Kirchhof method in the dynamics of a heterogeneous elastic medium** (in Russian), *Vestn. Leningrad. In-ta* no. 13, 146–160, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6956.

In the first part of the paper the Stokes formula is deduced which solves the Cushi problem for a homogeneous isotropic elastic body. Here the author makes very wide use of the generalized function (the unit function and Dirac's function). Initially the fundamental solutions are obtained and then, with the help of the Green-Volterra formula, the Stokes formula is obtained. In the second part of the paper, for the purpose of deriving the principal terms for the fundamental solutions of the equations for the motion of a heterogeneous isotropic medium

$$(\lambda + \mu)\ \text{grad div}\ u + \mu \Delta u + \text{div}\ u\ \text{grad}\ \lambda + 2D\ \text{grad}\ \mu - \rho \frac{d^2u}{dt^2} + X = 0$$

a method is used which the author had applied to the plane problem [*Vestn. Leningr. Un-ta*, no. 1, 1956]. The method is based on the use of a central field of extremals for the integrals

$$\int_{M_0}^{M} \sqrt{\frac{\rho}{\lambda + 2\mu}}\, ds, \qquad \int_{M_0}^{M} \sqrt{\frac{\rho}{\mu}}\, ds$$

and also by drawing upon the process of generalized functions. As the result of using S. L. Sobolev's method [*Matem. Sb.* **1(43)**, 1936] a system of integral equations of the Volterra type was obtained for the determination of the components of the vector of transposition, solving Cushi's problem. Proof of the existence of solutions emerges from the method of successive approximations, which can be applied here. I. S. Arzhanyikh

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**68. Meshkov, A. I., Equilibrium of an elastic parallelepiped** (in Russian), *Vestnik Mosk. In-ta Ser. Matem., Mekhan., Astron., Fiz., Khim.* no. 2, 35–43, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5663.

The energetic method proposed by M. M. Filonenko-Borodich for the investigation of the stressed state in three-dimensional problems in the theory of elasticity [*Prikl. Mat. Mekh.* **15**, no. 2, 1951; **17**, 4, 465–469, 1953] is utilized in the case of an inclined parallelepiped. For this purpose oblique-angled coordinates are brought into the investigation and, in particular, an expression for the potential energy of defonnation of unit volume through the counter variants of the components of the stress tensor. Further, a calculation is effected for the stressed state during the torsion of a straight parallelepiped, with a cross section in the form of a parallelogram, caused by forces distributed in conformity with the determined principle along the upper and lower ends; the second calculation relates to the case of temperature stresses in a straight parallelepiped. The correcting tensors for stress are used in the form of the product of trigonometrical functions of cosine-binomials. A. I. Lur'e

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**69. Meshkov, A. I., Some problems on the equilibrium of an elastic parallelepiped** (in Russian), Avtoref. Diss. Kand. Fiz.-Matem. Nauk, MGU, Moscow, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5677.

**70. Silin, V. A., Distribution of stresses and deformations in test samples when they are subjected to compression, tension and torsion** (in Russian), *Trudí Ukr. N.-i. In-ta Mestn. i Toplivn. Promsti* no. 10, 98–109, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6117.

A graphoanalytical method is proposed which permits the determination of wedge-shaped nondeforming regions of compression of materials in samples, of planes of slip and regions of shear; the relation is noted for the approximate determination of the coefficient of transverse deformation of the metal by the angle of shear, obtained when the sample fractured. Experimental data are furnished. An attempt is made to extend the graphoanalytical method to take in the study of the distribution of stresses in grooves, fillets and orifices. A. M. Sinyukov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**71. Mohan, M., A two dimensional mixed boundary value problem of elasticity for cardioid** (in English), *J. Sci. Engng. Res., India* **1**, 2, 203–212, July 1957.

Muskhelishvili method is used to obtain expressions for stresses and displacements in elastic medium bounded by a cardioid. Displacement is prescribed along one portion of the boundary, stress along the remainder. Both functions are represented by polynomials in the complex variable $z$, thereby satisfying identically the equilibrium conditions on the boundary. Specific example is considered in which boundary near cusp is stress free and remainder displaces proportional to $z$. Values of boundary stress associated with this displacement are calculated.

W. E. Jahsman, USA

**72. Nowacki, W., On certain boundary problems of the theory of elasticity** (in English), *J. Sci. Engng. Res., India* **1**, 1, 29–36, Jan. 1957.

Paper is attempt to generalize existing methods of finding the loads and/or displacements in statically indeterminate structures to continuous elastic systems. Treatment is very theoretical and reviewer doubts the possibility of applying it to practically useful cases, except perhaps when system is a disk or plate. Value of paper would be greatly enhanced by including a worked example.

D. M. A. Leggett, England

**73. Hugi, H., States of stress in semi-infinite regions and conformal mapping** (in German), ETH, Mitt. Inst. Baustat., Zurich, no. 33, 105 pp., 1957.

Paper concerns the solution of problems in the theory of plane elasticity on the basis of complex variables. After reviewing the theoretical basis established by N. I. Muskhelishvili, author, led by the fact that the form of sheaves and plates determines in great measure the difficulty of calculation, tries to solve the problem by using conformal mappings. He thus obtains simple systems, i.e. semiplane, circle, etc. The calculations and results obtained by conformal mappings and complex expressions lead to mathematical formulas suitable for the theory of plane elasticity. Author studies rational functions or even polynomials by conformal mappings as well as the approximation of any functions by rational expressions, covering in this way a large number of problems in the field.

C. S. Pelecudi, Roumania

**74. Graham, A., Numerical regularities in uniaxial deformation** (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **8**, 227–234.

**75. Sonntag, G., The semi-infinite plane composed of frictionless superimposed layers of equal thickness and subjected to periodical, distributed edge loads** (in English), 9th Congrès Intern. Mecán. Appl., Univ. Bruxelles, 1957; **7**, 360–363.

**76. Sharma, B., Stresses due to shearing force on a plane boundary of an infinite elastic slab with transverse isotropy,** Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956, 75–80.

Author presents a solution of the problem of infinite elastic slabs with transverse isotropy when shearing forces are symmetrically distributed. The equations of equilibrium in cylindrical coordinates are first solved, and solutions are then presented for infinite slabs.

A. G. H. Dietz, USA

**77. Chattarjee, P. N., and Dutt, D., Uses of an electric potential analogue computer to solve some elasticity problems,** Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 329–340.

Paper solves certain elasticity problems requiring the solution of either Laplace's or Poisson's equation by means of an electrical analog involving the potential distribution in a two-dimensional conductive field. An electric conducting paper (trade name—Teledeltos) is used as a model cut to the same shape as the boundary of the elastic member. Analog results are compared with analytical solutions for torsion of a rectangular bar, shearing stresses in a beam with elliptic section, and deflections of a simply supported triangular plate. Similar work of other authors is reported.

W. B. Stiles, USA

**78. Blackman, J. S., Smith, G. M., and Young, L. E., Stress distribution affects ultimate tensile strength,** *J. Amer. Concr. Inst.* **30**, 6, 679–684, Dec. 1958.

**79. Bijlaard, P. P., Thermal stresses and deflections in rectangular sandwich plates,** *J. Aero/Space Sci.* **26**, 4, 210–218, Apr. 1959.

For a constant temperature difference between the surfaces of the plate, author obtains equations for bending and torsional moments, transverse shear forces, and edge reactions in the plate under various edge conditions. Author uses three boundary conditions to get the proper effect of the transverse shear, instead of the two boundary conditions in classical plate theory which do not give the proper results for transverse shear. However, for the case of the plate simply supported at four edges, author says the transverse shear forces are zero and gives the classical solution together with its infinite moments and reactions at the corners. When transverse shear forces are considered, author's Eq. [6] is incorrect and should be replaced by his Eq. [39]. With this correct equation, the transverse shear forces are not necessarily zero for the plate simply supported at four edges.

B. E. Gatewood, USA

**80. Przemieniecki, J. S., Thermal stresses in rectangular plates,** *Aero. Quart.* **10**, 1, 65–78, Feb. 1959.

By writing Airy stress function under the form of a generalized Fourier expansion, author elaborates an approximate method for calculating the thermal stresses acting in a flat thin rectangular plate. Considering that the plate is subjected to an arbitrary temperature variation (whose Laplacian is expressed as a power series or a Fourier series) and putting the condition that the stresses vanish at the edges, the problem is reduced to solving a linear system of equations which yields the coefficients of the stress function. This system is particularly suitable for iteration.

Auxiliary tables for calculating the coefficients and an interesting practical example are included.

R. I. Priscu, Roumania

**81. Flugge, W., and Conrad, D. A., Thermal singularities for cylindrical shells,** Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 321–328.

Singular solutions of the equations of the shallow cylindrical shell, or alternately of the Donnell equations of the complete cylinder, are presented. It is shown that two of these solutions may be physically interpreted as thermal singularities, i.e., plane and bending hot spots. It is further shown that the concentrated force is not included among the solutions presented. Suggestions are made for applying the singularities to the solution of cylindrical shells with arbitrary temperature distribution.

From authors' summary by R. L. Bisplinghoff, USA

**82. Lakshmikantham, V., and Ramakanth, J., Non-linear deformation of aelotropic bodies,** Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 163–174.

Authors present analytical solutions for the problems of the spherical shell and the hollow circular cylinder subjected to uniform internal and external pressure, when the materials of which the objects are composed possess transverse isotropy. Solutions of the differential equations are given and proved to converge.

A. G. H. Dietz, USA

**83. Narayana, G. L., Torsion of isotropic and composite materials,** Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 137–144.

From a solution of Laplace's differential equation and in polar co-ordinates, torsion stress functions are presented for simple cross sections (circle, ellipse, triangle) composed of one isotropic material. Method is extended to cover concentric circles and ellipses made up of two isotropic materials.

P. W. Whitton, England

**84. Chattarji, P. P., Torsion of a large thick plate having transverse isotropy,** Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 129–136.

Problem is defined in terms of stress function and compatibility equation, whose solution is sought by writing stress function in the form of exponential integral. Pure torque is applied to opposite faces but solution is valid for case of one face fixed to rigid base. Concentrated torques on opposite faces are also considered.

C. Riparbelli, USA

**85 Chebanov, V. M., Solution of the problem of the torsion of prismatic stanchions by the method of the membrane analogy** (in

Russian), *Uch. Zap. LGU* no. 217, 288–294, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5694.

For the determination of stresses in stanchions of different sections being subjected to torsion author adopts the device evolved by V. I. Blokh, based on the membrane analogy [Trudi of the Conference on optical method, Leningrad, 1937]. The soapy film is drawn over the contour of the same form as the section of the stanchion. Above the film a grid is placed with dark and light squares, arranged chess-board fashion. At the center of the grid a camera is trained by which a record is made of the squares, distorted with the reflection of the light rays from the buckled film. From these photographs approximate values can be found for the components of the angles of rotation of the normal to the membrane surface at that or another point; from them it is possible to pass over to the stresses. According to author's statement the device is also furnished with a small screen, placed between the film and the small electric bulbs, arranged along the contour of the grid. In addition, the box, over whose top the film is drawn, should be partially filled with water, so that the film is not subjected to the action of a straight current of air. Using a similar apparatus, stresses were determined for cases of elliptical and rectangular (with ratios for the sides of 1 : 1 and 1 : 2) sections and also for a section in the form of an equilateral triangle. A comparison with known theoretical formulas is given. A. S. Vol'mir

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**86. Loo, T.-T., A second approximation solution on the elastic contact problem** (in English), *Scientia Sinica* **7**, 12, 1235–1246, Dec. 1958.

The known Hertz theory can only be regarded as the first approximation solution of the elastic contact problem. In 1947, Cattaneo obtained a second approximation solution for two solids of revolution having a common axis of symmetry normal to the plane of contact OXY. Author deals with a second approximation solution of a more general problem of contact of bodies having two common planes of symmetry OXZ and OYZ, the surfaces of which can be expressed in the form

$$z = ax^2 + by^2 + a'x^4 + b'x^2y^2 + c'y^4$$

If the contact area is assumed to be an ellipse, the unknown function of pressure distribution over the area of contact ellipse may be found by solving a certain integral equation. For the special case of two solids of revolution this solution agrees exactly with that obtained by Cattaneo.

The solution is applied to the problem of contact between a ball and the outer race of a ball bearing.

Z. Horak, Czechoslovakia

**87. Frasier, J. T., Displacement discontinuity on the interface of two joined dissimilar semi-infinite elastic solids,** *J. Appl. Mech.* **25**, 2, 292–293 (Brief Notes), June 1958.

**88. Teplitskii, E. I., The combined plane contact problem in the theory of elasticity and the theory of boundary equilibrium** (in Russian), Sb. Trudi Kafird. Vyssh. Matem. i Teor. Mekh. Moskovsk. Inzh.-Stroit. In-ta no. 1, 49–71; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5786.

The classical problem is investigated of the impressing of a plane centrally loaded stamping machine into a plastic medium, the process conforming to Coulomb's condition of plasticity. It should be noted that up to date there is no solution available for the similar, if somewhat more simple, problem for the medium conforming to the Tresca-Mizets condition for plasticity. The attempt to formulate an approximate solution for the problem given in the title was made by V. A. Florin [*Sb. Gidroenergoproekta* no. 2, 1937] who held the view that the pressure outline on the sole of the stamping machine would be linear in the plastic zone but that in the elastic zone it would retain an outline corresponding to the pure elastic solution. In analogous circumstances a more detailed examination was made of this problem by M. I. Gorbunov-Posadov [*Sb. Tr. N.-I. In-ta Osnovanii i Fundamentov* no. 3, 1949], who was of the opinion that at the edge of the stamp the pressure is determined by means of the theory of the boundary equilibrium of a free flowing medium. I. Ya. Shtaerman [*Sb. Tr. Mosk. Inzb.-Stroit. In-t* no. 14, 32–56, 1956] was able to obtain a more precise approximation; he determined the outline of pressure under the stamp in the elastic zone with consideration for the influence of pressure in the plastic region, being looked at as a "supplementary load."

Author has endeavoured to improve on the precision of Shtaerman's solution, while rejecting the hypothesis regarding the linear distribution of the pressures in the plastic zone. His idea consists in the merging of the given elastic-plastic problem with the pure elastic. With this objective, regions of plastic deformation are separated from the medium (such regions, symmetrically disposed in relation to the center of the stamp, are two in number). The stresses on the elastic-plastic boundary are assumed to be known from the theory of boundary equilibrium. The material in the zone of boundary equilibrium is assumed to be elastic, and along the free surface of this material loads are applied determined from the equations of the theory of elasticity. These loads are investigated as would be Shtaerman's "supplementary loads." The coordinates of the elastic-plastic boundary and of the values of the "supplementary loads" are determined from the system of three nonlinear integral equations, expressing on this boundary the continuity of the normal and tangential stresses and the conditions of plasticity. The solution of the system of integral equations was sought in an approximate form, so that it would only satisfy (the condition of) the limitation on the number of points. Thereupon, the problem leads to the solution of a system of nonlinear algebraical equations. To illustrate the method a numerical example is given. To simplify the calculations the author (purposely) assumes that the elastic-plastic boundary coincides with one of the lines of slip. The results of the calculations on this assumption were not satisfactory.

In the abstractor's view the method of the author, notwithstanding all his painstaking labor, cannot impart further precision to I. Ya. Shtaerman's results because the given problem is not related, apparently, to the class of statically determinable elastic-plastic problems, in which the field of stresses in the plastic zone is only determined by the external load applied to the boundary of this zone and does not depend on the distribution of stresses in the elastic region. The drawing by the author of the statically determinable field of lines of slip appears to be wholly arbitrary. It is very clearly unconnected with the possible field of velocities and contains inadmissable features (disruptions of the continuity of stresses at point B) in the sole of the stamp. Terms introduced in the paper are not defined; there are also misprints and inaccuracies (e.g., at p. 54, the angle of rotation of the stamp is termed a settlement, etc.). G. S. Shapiro

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

## Viscoelasticity

(See Revs. 4, 135, 138, 200, 203, 211, 522)

## Plasticity

(See also Revs. 122, 133, 144, 176, 201, 224, 225, 394, 471, 522)

**Book—89. Uzhik, G. V., Strength and plasticity of metals at low temperatures** (in Russian), Moscow, Izd-vo Akad. Nauk SSSR, 1957, 192 pp., illus. 7r. 50k; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5807.

The principal object of the book is the subject dealt with in Chapter I: to offer an explanation for the contradictory effects of lowering the temperature on the strength of metals, resulting in some cases in an increase of strength, in others in numerous brittle fractures. Cases of collapse and breakdown are described in Chapter II (bridges, reservoirs, ships). An exposition of the theory underlying cold fracture is given in the third chapter. In Chapter IV methods are described and discussed for the testing of metals for any indications of their tendency to brittle fracture. The author, in common with many Soviet specialists (in this field), attaches most importance to the so-called third portion of the diagram for the statical bending of the notched sample, that is to the area of the diagram after the load has passed its maximum. Total absence of the third portion (disruption) is evidence of the dangerous incapacity of the material to resist the propagation of the once-formed (still viscous) crack. Investigation of the distribution of stresses and deformations in the tensioned notched samples is dealt with in Chapter V. It is shown that as the deformation develops from the base of the notch into the inner part of the sample the limit of flow (yield) increases uninterruptedly. If in this process the stress attains the level of brittle stability, then a break-away with no deformation takes place; resistance to such a breakaway can only be found approximately.

The influence of stress concentrators on strength at low temperatures is examined in Chapter VI. It is shown that lowering of the temperature creates favorable conditions for the emergence of brittle fracture. The author refers to the works of Wood and Clark, who observed for steel a delayed yielding, and makes use of this circumstance to explain the dangerous influence exercised by the velocity of deformation, comparing the duration of loading with the magnitude of this "incubation" period. The danger of brittle fracture reaches its maximum under combinations of a high rate of loading, a large concentration of stresses and a high limit of yield (a low temperature). Valuable data are given in Chapter VII on the raising of the limit of yield of different metals with increases of temperature from room temperature to minus 183°. Chapter VIII describes results of testing metals to the disruption point at the temperature of liquid hydrogen (−253°). Differing from the previous somewhat scanty investigations at this temperature, author succeeded in devising apparatus which enabled him to use an ordinary 7–8 ton testing machine for tension tests of samples of large diameter and to record tension diagrams with determination of the limit of yield. In this series of tests the author was able to obtain brittle fracture of a number of steels for which the temperature of liquid nitrogen was not sufficiently low. In this chapter too the author looks for the answer to the question of the identical nature of brittle stability when two methods are employed for its determination: by means of lowering the temperature or by using the method of notching. Having now new data for brittle stability at −253°, determined on smooth samples, author compares this with the results obtained with the same steel on notched samples at room temperature and obtained satisfactory convergence.

The comparison carried out by the author between the brittle stability and limit of yield is interesting. Although in its widest sense the increased value of the limit of yield is linked with the increased brittle stability, the link, as one would naturally expect, is so weak that it is impossible to read into it any sign of a determinable principle. Some data are given for the fatigue resistance of a few steels and alloys. As has already been shown earlier, the lowering of the temperature, generally speaking, causes a rise in Wochler's curve; notches, however, may cause the lowering of the limit of fatigue. There is a supplement of 35 tables in the book. These embody data on the mechanical properties of metals and alloys at low temperatures, collected from different sources.

N. N. Davidenkov

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**90. Boyce, W. E., The elastic-plastic bending on an eccentrically loaded sandwich column,** *J. Aero/Space Sci.* **26,** 6, 398–399, (Readers' Forum), June 1959.

Extending the investigation of earlier work on plastic behavior of straight sandwich column loaded by eccentric forces parallel to axis of column, author now treats elastic effects and assesses their importance. The load at which column becomes fully plastic is shown to be independent of its elastic properties, and the later behavior of column becomes even independent of yield stress. Instability sets in at the tangent modulus load of classical theory.

S. K. Ghaswala, India

**91. Payne, H., The slip theory of plasticity for crystalline aggregates,** *J. Mech. Phys. Solids* **7,** 2, 126–134, Mar. 1959.

A model for predicting the plastic behavior of a crystalline aggregate under uniaxial stress from empirical data on slip in the single crystal has been developed by Taylor and has been modified by Bishop and Hill, and by Lin. Taylor treated the specimen as perfectly rigid except for the occurrence of slip. He pursued a linear strain path, i.e., a path along which the ratios of the strain tensor components are constant, in the plastic region. Lin also assumed a linear strain path but removed the restriction that the specimen be considered as rigid except for slip. It is the purpose of the paper under consideration to present, in mathematical language, the extension of this model to render it capable of predicting the complete stress-strain relation for a polycrystalline material following a nonlinear strain path.

F. Chmelka, Austria

**92. Whiteman, I. R., A mathematical model depicting the stress-strain diagram and hysteresis loop,** *J. Appl. Mech. (Trans. ASME,* Series E) **26,** 1, 95–100, Mar. 1959.

A model is made up of elastoplastic elements, all of which have the same value of Young's modulus $E$, but which have different values of yield stress. It is shown that the dimensionless tangent modulus graph $E_t/E$ represents the cumulative frequency distribution of those elements which are in the elastic region. From the frequency distribution, the equations for the stress-strain diagram and the hysteresis loop can be written.

From author's summary by G. W. Housner, USA

**93. Drucker, D. C., A definition of stable inelastic material,** *J. Appl. Mech. (Trans. ASME,* Series E) **26,** 1, 101–106, Mar. 1959.

The definitions given previously for work-hardening and perfect plasticity are broadened to cover viscous effects. As before, the system considered is isothermal and includes both the body and the time-dependent set of forces acting upon it. An external agency is supposed to apply an additional set of forces to the already loaded body. It is now postulated that the work done by the external agency on the additional displacements it produces is positive. Some of the restrictions thus imposed on permissible stress-strain relations are explored. Especial attention is paid to simple laws of creep. Uniqueness of solution also is studied.

From author's summary by G. W. Housner, USA

**94. Ito, K., Frozen strain in high polymer solids and its application to molding of plastics,** *Scient. Pap. Inst. Phys. Chem. Res., Tokyo* **52,** Pap. 1492, 17 pp., Dec. 1958.

Paper describes experimental investigation into the behavior of high polymer solids, mainly in compression. Results are explained in terms of internal molecular structure, epoxy cast resin (Araldite) being termed "network" polymer and hard polyvinylchloride (P.V.C.), "linear" polymer. Author suggests that straining of cross-linked polymers ("network" type) is related solely to

"intra-molecular micro-Brownian motion" which he calls "deformation" strain, while straining of linear polymers is supplemented by "inter-molecular micro-Brownian motion" which he calls "flow" strain.

Author shows that "deformation" strain is not truly permanent but is merely frozen by secondary bonding forces and can be removed by an annealing process. The straining of linear polymers is more complex due to the added "flow" strain, which is analogous to the plastic strain of a metal and therefore of permanent character. The effect of strain rate and temperature was also investigated and it was found that at room temperature the "flow" strain in P.V.C. was small, while at about 200 C the deformation strain became negligible. Some examples of practical application of strain freezing are described.

J. M. Alexander, England

**95. Likhtman, V. I., and Ostrovskii, V. S., The mechanism of plastic flow of lead and tin in conditions of simple shear,** *Soviet Phys.-Doklady* **3,** 2, 406–408, Dec. 1958. (Translation of *Doklady Akad. Nauk SSSR* (N. S.) **119,** 3, 484–487, Mar.–Apr. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

**96. Halling, J., The characteristic method of solution for the problem of plane plastic strain,** *Engineer, Lond.* **207,** 5377, 250–254, Feb. 1959.

Paper is a short clear exposition of the theory and its application as developed by authors mentioned at end of the paper.

W. M. Shepherd, England

**97. Zubov, V. Ya, Structural bases of the plasticity and elasticity of a steel spring ribbon** (in Russian), Avtoref. Diss. Dokt. Tekhn. Nauk, Ural'skii Politekhn. In-ta, Sverdlovsk, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3509.

**98. Doroshek, S. I., Lapkin, N. I., and Shubin, G. N., The change in plasticity of steel transformer sheets during cooling** (in Russian), *Fiz. Metallov i Metallovedeniye* **4,** 1, 171–176, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2344.

Certain problems are investigated of the kinetics of the change in plasticity of hot-rolled transformer-grade steel during cooling following a low-temperature anneal without a protective atmosphere. By a method of stepwise cooling after annealing, the influence of the rate and temperature range of cooling on the plasticity of transformer steel has been determined. It is found that, during the cooling process, the plasticity of the steel changes according to a curve having a maximum. The position of this maximum depends on the conditions of heat-treatment and the previous critical limits attained. The conception of the nature of embrittlement in transformer steel is given a more precise formulation.

From authors' summary

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**99. Dekhtyar, I. Ya., The influence of defective crystalline structure on the mechanical failure of metals** (in Russian), Strength of metals, Moscow, Akad. Nauk SSSR, 1956, 27–35; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2376.

It is found that the influence of defective crystalline structure of the type of the vacancies appearing in thermal expansion, electrical resistance, diffusion, etc., also has a material influence on the phenomena of creep and mechanical failure of metals.

From author's summary

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**100. Kuleshov, P. I., The relationship between the yield point in torsion of metallic crystals of the hexagonal type and their orientation** (in Russian), *Trudi Donetsk. Industr. In-ta* **19,** 47–52, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2377.

The yield point in torsion is calculated for hexagonal crystals; it is shown that the yield point depends fundamentally on the angle between the axis of the sample and the hexagonal axis. It is found that the influence of orientation on the magnitude of the yield point is very substantial, and that there are orientations at which slip is generally impossible.

From author's summary

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**101. Yushchenko, O. A., One case of axial symmetrical deformation with ideal plasticity** (in Ukrainian), *Dopovidi Akad. Nauk URSR* no. 1, 18–22, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 1000.

The ultimate state is examined of a ring which is subjected to axial and internal hydrostatic pressure. It is assumed that the axial normal stress does not depend upon the ring thickness. The critical hydrostatic pressure is obtained as a function of the ratio of external and internal radius. Author determines the external and internal radii of the ring which remains in the ultimate equilibrium, assuming that the thickness of the ring does not vary with the radial coordinat

A. M. Kochetkov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**102. Hopkins, H. G., On the plastic theory of plates,** *Proc. Roy. Soc. Lond.* (*A*) **241,** 1225, 153–179, Aug. 1957.

**103. Ayanyan, E. M., Plane elasto-plastic equilibrium of a pulverulent medium in the vicinity of a cylindrical cavity** (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 137–140, Apr. 1957.

**104. Colonnetti, G., General theory of elastic-plastic equilibrium** (in French), *Bull. Centre Études Genie Civ.* **9,** 101–116, 1957.

**105. Landau, H. G., and Weiner, J. H., Transient and residual stresses in heat-treated plates,** *J. Appl. Mech.* **25,** 4, 459–465, Dec. 1958.

Equations are given for determining transient and residual thermal stresses in a heat-treated plate. The material of the plate is assumed to be elastic, perfectly plastic. The temperature is assumed uniform on any plane parallel to the faces of the plate but can vary arbitrarily in the direction normal to the face and in time. The stress distribution during the unloading period is determined exactly without the simplifying assumption of simultaneous unloading. Application is made to the determination of stresses during cooling of a uniformly heated plate. The stress-distribution sequence and residual stresses are calculated for several values of cooling rate and yield stress.

From authors' summary by H. G. Hopkins, England

**106. Boyce, W. E., A note on strain hardening circular plates,** *J. Mech. Phys. Solids* **7,** 2, 114–125, Mar. 1959.

Using Prager's piecewise linear strain-hardening plasticity, one of the first problems solved was that of a uniformly loaded simply supported circular plate. It proved impossible, at least with similar methods, to solve the corresponding problem for a clamped plate. Author extends the previous solutions to plates which are partially clamped, using Tresca's yield condition and the above-mentioned hardening law. As an introduction, a brief review of Prager's theory is given.

F. Chmelka, Austria

## Rods, Beams and Strings

(See also Revs. 36, 77, 83, 131, 165)

**107. Mehmel, A., Contribution to the calculation of elastic and plastic deflections in under-reinforced concrete beams** (in German), *Bauingenieur* **34,** 1, 9–11, Jan. 1959.

In view of the increasing allowable stresses in both concrete and steel (DIN 1045), followed by a greater deflection in slender beams, author analyzes the problem in the elastic and plastic range. The creep is considered by a smaller elastic modulus $E_{b\varphi} = E_{b0}/1 + \varphi$, with $E_{b0}$ = const; only a dead load produces plastic deflections; the deflections are a function of the stresses $\sigma_e$ (steel) and $\sigma_b$ (concrete). The final values are given for a final creep ($\varphi = 3$); also the deflections as function of the creep ($\varphi_{initial} = 0$, $\varphi_{final} = 3$) are analyzed. The calculations are simplified by introducing two correction factors: (1) $\kappa_1$ and $\kappa_2$ (without or with shrinkage), (2) $\kappa_3$ which gives the partial plastic deflection. A numerical example is given for a ratio span/height = 15. The method is of general validity (elastic or ultimate strength design).

The problem is considered in the new Soviet design code of 1955 in another form (Chap. VIII and tables 9–10).

A. M. Guzman, Argentina

**108. Thon, R., Contribution to the calculation and measurement of continuous flat beams** (in German), *Beton u. Stahlbeton.* **53,** 12, 297–306, Dec. 1958.

A Fourier series analysis is applied to the plane stress problem for an infinitely long strip. A periodic distribution of normal loading is applied to one side only. In each period of length $a$ the loading consists of a uniform compression over a length $c$ and a balancing uniform tension over the remainder $a - c$. Numerical computations are carried out for the Cartesian stress components, their principal values and directions, and certain force and moment resultants over internal sections. The results are presented in considerable tabular and graphical detail for $c/a = 1/10, 1/5, 1/2$ and for $b/a = 1/2, 2/5, 1$, where $b$ is the strip width.

R. Hill, England

**109. Kirste, L., Minimum weight compression rods** (in German), *Öst. Ing.-Arch.* **12,** 1/2, 36–41, Nov. 1958.

Paper first introduces a modified version of Johnson's formula for short columns by postulating that for zero slenderness ratio the column load capacity for overall buckling be equal to the load capacity for local crippling. This is an analytically convenient assumption; yet it is to be seen how realistic it is for a given specific combination of material and cross section. No supporting evidence is mentioned in the paper. On the basis thus established, minimum-weight design criteria are developed for thin-walled round, hexagonal and octagonal tubular compression members.

O. Hoffman, USA

**110. Tarnopolsky, Yu. M., The three-dimensional work of a curved bar in a generalized elastic medium** (in Russian), *Izv. Akad. Nauk LatvSSR*, no. 1, 111–120, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2214.

An examination of bending and torsion of a flat, circular bar contained in a continuous, elastic medium. The latter is characterized in that the reactive forces and moments developed in it are determined at every point on the axis of the bar by a linear combination of corresponding displacements in the direction of the binormal and the angular rotation of the cross section with reference to the tangent to the axis of the round bar. For a bar of constant cross section and an elastic medium with constant coefficients of yielding, the fundamental differential equation of the problem is obtained. The strength analysis of a bicycle-wheel rim is examined, the spokes being regarded as a continuous, generalized elastic foundation.

D. V. Vainberg

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**111. Gorgidze, A. Ya., Problem of the reciprocal influence of a bending of a beam by a transverse force on a bending by a couple** (in Russian), *Trudi Tbilissk. Matem. In-ta* **22,** 251–263, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 960.

The reciprocal influence of bending by a transverse force and by a couple is investigated in a beam composed of a series of parallel solid bars welded together along their side surfaces. The Poisson coefficients of materials of these bars are assumed to be equal but the moduli of elasticity are generally different. The problem is solved by the method developed in the works of N. V. Zvolinskii, P. M. Riz and D.Yu. Panov, and also adopted by A.Ya. Gorgidze and A. K. Rukhadze in the solution of some problems of secondary effects.

O. M. Sapondzhyan

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**112. Frank, W., and Nordmann, E., Theoretical investigations of the influence of the supports upon the rigidity of beams** (in German), *Maschinenbautechnik* **7,** 9, 478–481, Sept. 1958.

Authors consider a centrally loaded beam resting on idealized inboard-outboard linear spring supports. The effects of spring stiffnesses and distances are computed and plotted. A certain combination of the latter is found to yield an optimum rigidity of the beam-spring system.

E. E. Zajac, USA

**113. Sundara Raja Iyengar, K. T., Analysis of deep beams,** Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956, 87–94.

The analysis of a deep rectangular, single-span beam under symmetrical loading is developed. The multiple Fourier procedure is employed, using four series by which it has been possible to satisfy all boundary conditions; the resulting relations among the coefficients are derived.

From author's summary by E. R. Johnston, USA

**114. Kuznetsov, V. I., Application of the method of initial parameters to the calculations of beams on an elastic isotropic foundation** (in Russian), Investigations in the theory of constructions, no. 7, Moscow, Gosstroiizdat, 1957, 167–185; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5909.

A known method is described of initial parameters applicable to the calculation scheme of a foundation in the form of a semispace. An examination is made of a beam with a rectangular base in plane (the sides of which are equal to $2a$ and $2b$, with $a \gg b$) under the action of a concentrated force along the center and in an arbitrary point, under the action of two concentrated forces, applied symmetrically relative to the center, and a continuously distributed load. Numerical results are given of the solutions for some special cases.

P. I. Klubin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**115. Arkhangorodskii, A. G., Belen'kii, L. M., and Chernyshev, O. L., A device for the calculations for beams lying on elastic supports and a continuous elastic foundation** (in Russian), Investigations in the theory of constructions, no. 7, Moscow, Gosstroiizdat, 1957, 575–586; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5922.

A device is described which acts as a mechanical calculator for redundant beams lying on independent elastic supports. The basic idea underlying the use of this device for the calculations of beams is as follows: the real beam is replaced, in corresponding manner, by a model similar to it, and the loads and the coefficients for the rigidity of the supports $k_i$ are modelled. The sag in the supports $f_i$ is measured on the device, and on the basis of these measurements calculations are made for the supports' reaction $R_i = k_i f_i$. Then the calculations are translated from the beam-model to the actual beam. By simple increase of the number of elastic supports a model can be constructed for a continuous elastic foundation. Examples of the calculations are given, and deductions are put forward envisaging an extension of the field of application of the described device.

P. I. Klubin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**116. Korotkin, Ya. I., Strength of coverings and plates, taking into account the rigidity encountered during torsion of the beams** (in Russian), *Trudi Leningrad Korablestroit. In-ta* no. 18, 13–22, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5744.

An investigation is made of the covering consisting of a large number of identical equally spaced longitudinal beams, supported on a series of identical equally spaced bars, and also of the strength of a plate reinforced solely by transverse bars, while taking into accout the rigidity of the torsion of the transverse beams (bars). It was shown that in both cases the problem divides into two special cases, namely: (1) the problem of the vibrations of the bars and (2) the problem of the strength of the bar on equally spaced elastic supports of a given rigidity, producing in it the same elastic fastening as for a bar with some measure of "give." This coefficient is only constant along the length of the bars when the ends are freely supported. Next, the problem is scrutinized of the strength of a bar on elastic supports, also possessing an elastic fastening; at this point an investigation is made of the magnitude of the critical deflection-rigidity of the bars. To solve the problem the method of angular deformations is used. The equations for stability are obtained from the conditions of equilibrium of the supports, from the equality to zero of the sum of the moments and transverse forces. To evolve these equations the author borrows P. F. Papkovich's ready-to-hand expressions for the bending moments and transverse forces through the sag and angles of turn and the tabulation of functions $A(u)$, $B(u)$ and $C(u)$, where $u = \frac{1}{2}l\sqrt{T/Ei}$. The determinations from the equations of the stability of the argument permits the finding of the Euler value of the compression force $T_E = (2u)^2 Ei/l^2$, and also the parameter, characterizing the critical rigidity of the elastic supports. The investigation continues for the cases where the number of spacings between the rods is equal to two, to three, and an infinite number. It appeared that only in the cases where the number of spacings between the rods was equal to two and in the infinity case do the intermediate supports possess a critical deflection rigidity; the latter increasing with the increase of elastic fastening of the supports. For rods having three or more interspacings no critical rigidity of elastic supports is apparent, and it is only in the case of absolutely rigid supports that it is possible to benefit in full from that increase in the Euler load which can be imparted by an elastic fastening. It should be noted that the influence of the rigidity of torsion of the bars on the strength of the coverings and plates when the correlation in dimensions is substantial appears to be inappreciable, amounting to one or two percent. V. P. Belkin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

## Plates, Shells and Membranes

(See also Revs. 72, 76, 77, 79, 81, 82, 96, 102, 105, 106, 144, 154, 156, 169, 201, 493)

**117. Bassali, W. A., and Nassif, M., Stresses and deflections in an elastically restrained circular plate under uniform normal loading over a segment,** *J. Appl. Mech. (Trans. ASME,* Series E), **26,** 1, 44–54, Mar. 1959.

For thin circular plate, authors determine deflections and stresses for cases where it is uniformly loaded along a chord and over a sector. They assume the deflection vanishes over the edge and that two moments are proportional. Numerical results based on this are included in tables and graphs.

J. L. Ericksen, USA

**118. Tomato, O., Transverse flexure of a thin plate containing two circular holes,** *J. Appl. Mech. (Trans. ASME,* Series E) **26,** 1, 55–60, Mar. 1959.

A theoretical solution is given for an infinite plate containing two circular holes of equal size under transverse flexure. Two fundamental cases of transmitting constant bending moments about the axis of symmetry are discussed on the basis of the classical Poisson-Kirckhoff theory. A method of perturbation is adopted for the determination of parametric coefficients involved in the solution.

From author's summary by J. G. Bouwkamp, USA

**119. Barg, Y. A., Determination of critical load of orthotropic and isotropic plates and beams** (in Ukrainian), *Prikl. Mekh.* **5,** 1, 18–28, 1959.

Author gives an experimental-analytical method for determination of a critical load for thin rectangular plates and beams by use of an analogy between two differential equations: of vibrations and stability. The critical load is determined by the following formula:

$$P_{cr} = (\omega_1^2/\pi^2) ML^2 l$$

where $P_{cr}$ = critical load in the $x$-direction
$\omega_1$ = frequency of the cardinal tone, which is determined by means of a vibrogram of free vibrations of the plates
$M$ = mass of the unit element of plate
$L$ = length of plate (in the $x$-direction)
$l$ = width of plate

The plate which is strengthened by means of a set of mutually perpendicular beams is considered as orthotropic.

The experimental data are given in three sets of tables. The bibliography refers to seven books and two papers.

P. Shuleshko, Australia

**120. Giencke, E., The calculation of continuous roadway plates, Parts I, II, III** (In German), *Stahlbau* **27,** 9, 229–237, Sept. 1958; **27,** 11, 291–298, Nov. 1958; **27,** 12, 326–332, Dec. 1958.

A stress analysis is presented for long orthogonal plates under normal loads with simply supported edges, at certain intervals supported by beams in crosswise direction. The plate stiffness is related to the stiffness of an isotropic plate with relatively light stiffeners in longitudinal direction placed at small and equal intervals. First the plate equations are solved for the case that all four edges of each bay are simply supported. Next the compatibility and equilibrium conditions at the supporting beams furnish a recursion formula with five bending moments as unknowns. It is shown how the analysis can be extended by the use of eigenfunctions to the case where there are more than two rigid supports in longitudinal direction, dividing the plate into two or more bays supported by continuous beams in crosswise direction. It is demonstrated how under various geometrical conditions accurate results can be obtained by a greatly simplified approximate analysis.

Reviewer feels that paper provides a very useful guide for the design of roadway plates. J. F. Besseling, USA

**121. Martisius, A., Calculations for rigid square plates on an elastic foundation** (in Russian), *Trudi Kaunassk. Politekhn. In-ta* **6,** 277–283, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5732.

Results are given of the experimental investigation on the distribution of the bending moments in the foundations below columns. Foundations having in plane the form of a square with a continuous and stepwise changing transverse section were investigated. The rubber models corresponding to these conditions formed cushions on which were loaded layers of cement paste. The pressure of the soil was reproduced in the model by the weight of the cement layer and the specific weight of the cushion in relation to the theoretical principle of the distribution of pressure in the case of a stamping machine. The hardened cement cast recorded the distorted surface of the originaliy flat surface of the model of the foundation. Based on measurements of the deformation at different points in the cast the bending moments were established by formulas derived from the stereometric method. The transverse forces were com-

puted by means of graphic differentiation. The investigational results were recorded in the form of curves. P. I. Klubin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**122. Joga Rao, C. V., The elasto-plastic problem of a thin rotating disk with a central circular hole and hyperbolic thickness variation,** Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 65–70.

A thin rotating disk is bounded by the surfaces $z = Cr^n$. Assuming that the material is elastic/perfectly plastic and satisfies Tresca's yield condition, author has found the complete elastic/plastic stress distribution in closed form for all speeds up to that at which the disk becomes fully plastic. It is assumed that $\sigma_\theta > \sigma_r > 0$ throughout; the assumption is shown to be valid in a particular example. P. G. Hodge, Jr., USA

**123. Roy, S. K., On the biharmonic analysis of stress fields for hydrostatic loading in relation to analytical relaxational and photoelastic results for openings in structures,** Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 71–92.

Problem of square plate with free outer edge and central circular hole under internal radial pressure is solved analytically with Airy's stress function in the form of a Fourier series, the constant and two harmonic terms of which provide sufficient approximation for numerical evaluation. The Fourier coefficients are found by satisfying outer boundary conditions at corners and centers of sides. Results for various ratios of hole diameter to square side from 0.1 to 0.9 are given in graphs directly useful to design, and compared with relaxation solution still to be published and photoelastic observation by Durelli & Barriage [*J. Appl. Mech.* **22,** 4, 539–544, 1955]. Coincidence with relaxation is very good; photoelasticity tends to underestimate stresses and author attributes this to experimental loading difficulties.

Author points out wider applicability of analytical solution in polar coordinates to other problems by superposition and calls for further solutions of general stress fields and standardization of biharmonic relaxation. M. L. Meyer, England

**124. Schwarze, G., Contribution to the stability of thin shells** (in German), *Beton u. Stahlbeton.* **53,** 11, 284–288, Nov. 1958.

It is shown that a simplified law of elasticity requiring little calculatory work produces results that are satisfactory for practical purposes. This simplification resides in the fact that, in regard to the forces of a section, all terms proportional to the flexural rigidity and, in regard to the moments of the section, all terms, with the exception of the highest derivatives of the displacement perpendicular to the surface, are omitted. Examples: 1. Circular cylindrical shell stressed (a) by constant external pressure and (b) by axial pressure and (c) by torsional moments. 2. Closed spherical shell stressed by constant external pressure. 3. Conical shell stressed (a) by its deadweight with its wall thickness being variable, and (b) by constant external pressure.

G. Sonntag, Germany

**125. Kirchner, G., About the calculation of long cylindrical shells** (in German), *Bauingenieur* **33,** 9, 331–336, Sept. 1958

"Beam" method and analytical method—called "mathematical" in the text (such as Donnell-like theory)—of calculation of long cylindrical shells are compared. Conclusion is that in such shells the assumption of linear distribution of the longitudinal stress $N_x$ across the depth entails negligible error. Also considered is the influence of variation of the $N_x$ forces from the straight line distribution; this influence is found to be reasonably small (+3% to −14% at the crown of an interior shell in the case of transverse bending moment).

Reviewer wishes to point out that in a recent paper of fundamental importance [R. S. Jenkins "A variational method for design of cylindrical shells," Proceedings of the Second Symposium on Concrete Shell Roof Construction, July 1957, pp. 157–167, Oslo, Norway, Teknisk Ukeblad] the range of applicability of the beam theory was greatly extended. S. J. Medwadowski, USA

**126. Herber, K.-H., Measurements on shell-type roofs with rib frame works** (in German), *Stahlbau* **27,** 9, 237–246, Sept. 1958.

Assuming that membrane and bending deflections calculated separately are simply additive, formulas are developed for calculation of bending moment and deflection of tank domes with ribs and rib-supported circular rings. For symmetric loads the segment included between adjacent ribs is approximated by a parabolic arc. This leads to closed-form expressions for the quantities of interest in design. The assumption is shown to be conservative as compared with a circular arc.

The effects of rib shortening and number of reinforcing rings are discussed, as are unsymmetrical loadings. Two numerical examples are worked out for various numbers of ribs and rings and for various rib cross sections. The computations are tabulated so that inferences may be made as to the most economical design.

Author shows that his design formulas are not contradicted by the more accurate ones of Klöppel-Roosbluth and Klöppel-Roos.

L. E. Goodman, USA

**127. Mushtari, Kh. M., and Kornishin, M. S., Convergence of Galerkin's method when determining the upper and lower critical limits of loading in a single nonlinear problem** (in Russian), *Izv. Kazansk. Fil. Akad. Nauk SSSR, Ser. Fiz.-Matem. i Tekhn. Nauk* no. 10, 27–30, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5700.

An investigation is made of an infinitely long cylindrical sloping shell subjected to the action of an external even pressure. Making use of the Bubnov-Galerkin method, authors calculate the upper $P_u$ and the lower $P_l$ critical loads for the given problem. On the basis of the calculations made it was shown that, in the case of a hinge-supported shell, for a wide range of parameter changes, the shells $P_u$ and $P_l$ are determinable with practical exactness in the second approximation. In the case of a fastened shell $P_u$ can be determined sufficiently exactly from the second approximation, $P_l$ only from the fourth approximation. In the two cases cited the Bubnov-Galerkin method gives an approximation for the exact value of $P_l$ from below. I. I. Vorovich

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**128. Zhgenti, V. S., Calculations for a sloping thin elastic shell, with the shape of a paraboloid of rotation, under the effect of a vertical concentrated force** (in Russian), *Trudi Gorliisk. Gos. Ped. In-ta* **3,** 299–306, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5708.

The shell described in the title is reinforced along the outer contour to withstand both linear and angular transpositions. A force is applied to the pole, in the direction of the shell's axis. The solution is carried out without any deductions. The components of transposition and the intensity of the internal forces and moments are presented through Bessel-Thomson functions, the argument having the form of

$$2r\sqrt{\frac{\lambda}{\delta}\sqrt{3(1-\nu^2)}}$$

where $\nu$ is Poisson's coefficient, $\delta$ the shell's thickness, $r$ the distance from the axis, while $\lambda$ is the parameter in the equation for the paraboloid $z = \lambda r^2$. It should be noted that the above argument can be conveniently put forward in the form of

$$2\sqrt{\frac{z}{\delta}\sqrt{3(1-\nu^2)}}$$

where parameter $\lambda$ is excluded. When setting-up the problem, two assumptions are introduced: (a) an undimensional (?) parameter $\lambda \ll 1$; (b) the region of the paraboloid being investigated is delimited by a radius $r_0$ when $4\lambda^2 r_0^2 \ll 1$. Notwithstanding the author's assertion the parameter $\lambda$ has a dimension (length)$^{-1}$, that being so assumption (a) is deprived of meaning. It can be assumed that the results obtained are guaranteed by the introduced tolerance (b). A reference is quoted to previous work by the author [*Prikl. Mat. Mekh.* **3,** 331–334, 1952] where, in the setting-up of the problem, assumption (a) is also introduced, while assumption (b) is factually made use of, if not actually formulated.

Ya. B. L'vin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**129. Vocke, W., Calculation of cylindrical container with quadratically varying wall thickness** (in German), *ZAMM* **37,** 9/10, 399–400, Sept./Oct. 1957.

Isotropic elastic circular cylindrical shell with axially symmetric loading is considered. Thickness is quadratic function of axial coordinate. Closed solution is obtained for complementary function of differential equation of small-deflection theory.

H. L. Langhaar, USA

## Buckling

(See also Revs. 150, 151, 201)

**Book—130. Kollbrunner, C. F., and Meister, M., Buckling, theory and computation of plates [Ausbeulen, Theorie und Berechnung von Blechen],** Berlin, Springer-Verlag, 1958, xi + 344 pp. DM 42.

This is a monograph devoted to buckling problems of plates occurring in engineering structures.

Contents: 1. Historical introduction; 2. Theory of buckling of plates. In this chapter the fundamental differential equation of deflection surface of the plate is developed. The method of direct integration of the differential equation, the strain energy method and numerical methods in calculating the critical loads are discussed; 3. Various buckling cases of plates. The critical load in elastic and inelastic range is computed for rectangular plates under various edge and loading conditions; 4. Plates reinforced by ribs; 5. Plates with disturbances; 6. Large deflections of plates.

References are made to all important papers on buckling of plates in the world literature. Many numerical tables are inserted in the text. The book is very useful for a construction engineer.

A. Ylinen, Finland

**131. Schmidt, K., On the computation of strain of noncircular pipes under external pressure, Part I: The buckled original cylindrical pipe; Part II: The original elliptic pipe** (in German), *ZVDI* **101,** 2, 47–54, Jan. 1959; **101,** 4, 126–130, Feb. 1959.

Author considers an infinitely long thin-walled cylinder subjected to external pressure. In the first part of the paper he studies the finite deflection of a circular tube loaded with a pressure slightly greater than the critical one. He assumes the surface of the buckled pipe in the form of a cylinder of a deformed profile. For that reason the whole problem reduces to a problem of the buckling of a curved beam. Two diagrams show the relations between the pressure and the deformation of the profile of the tube.

In the second part author obtained the deflection and the corresponding stresses in the infinitely long elliptical tube under external pressure. From the numeral example it results that the neglect of finite deflections leads sometimes to considerable errors.

Z. Kaczkowski, Poland

**132. Habel, A., Buckling perpendicular to the plane of application of the force** (in German), *Beton u. Stahlbeton.* **53,** 8, 197–202, Aug. 1958.

Compressive force in a rectangular concrete or reinforced-concrete column will act eccentrically on the longer axis of the rectangle. Author seeks the limit of the eccentricity $p$ of compressive force that will set apart the buckling developed in the plane of the compressive force and that developed in a plane perpendicular to it. When dealing with concrete columns, author assumes the critical force of the buckling to be as shown in earlier works (of Jäger, Habel, Voellmy and Kordina) and presents tables for determining the critical force; he also draws a parallel between results and the recommendations of DIN 1047. He sets down the critical force of the buckling perpendicular to the plane of the beam by following up the example of the first critical force of Engesser. This process is made more comprehensible by his numerical calculation. As for reinforced-concrete columns he solved the same problem 20 years ago [*Beton u. Stahlbeton.* **15,** p. 251, 1939], supplying now additional tables for practical application.

Author concludes that in cases of both concrete columns and reinforced ones, buckling developed perpendicularly to the plane of the compressive force may occur only when $p$ values are exceedingly small. The latter type of inquiry may always be replaced by another one, disregarding any $p$ values and determining the critical force centric according to the following terms: (1) slenderness to be calculated from the narrower dimension; (2) an eccentricity should be allowed for non-eliminable errors. This, in case of concrete columns, should amount to $m_0 = p/k = 0.15 + \lambda/300$; in case of reinforced columns to $m_0 = 1/400$. In case of $\lambda > 20$ the DIN 1047 will result in larger dimensions than those obtained by the calculation method recommended here.

Reviewer believes that author's calculations will come up to requirements in practical use, though they do not seem to be perfectly correct theoretically, as may be gathered from the comparison the author effected with the case of steel bars. In the latter case, the suggestion does not seem to be quite acceptable that the eccentricity of the force has no influence at all on the load-bearing capacity taken in perpendicular sense to the plane of the force because of the possible torsion that may take place while buckling [see Timoshenko, *J. Franklin Inst.*, 1945]. This effect is, of course, negligible in case of concrete or reinforced-concrete columns.

I. Koranyi, Hungary

**133. Goder, W., Buckling of columns with variable cross-sections in the plastic region** (in German), *Stahlbau* **27,** 7, 188–190, July 1958.

**134. Goldberg, J. E., Lateral load analysis of two-column bents,** *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 3, (*J. Struct. Div.*), Pap. 1638, 18 pp., May 1958.

**135. Lin, T. H., Creep deflections and stresses of beam-columns,** *J. Appl. Mech.* **25,** 1, 75–78, Mar. 1958.
See AMR **11** (1958), Rev. 1619.

**136. Csonka, P., Buckling of straight rods, treated by the method of elastic points** (in Hungarian), *Magyar Tud. Akad. Musz. Tud. Akad. Musz. Tud. Oszt. Közl.* **22,** 1/3, p. 35, 1958.

**137. Spengler, I. E., The local stability of the walls of beams and their calculation** (in Russian), *Sb. Nauchn. Pr. Dnepropetr. Inzh.-Bud. In-ta* no. 3, 50–70, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7047.

Formulas for checking the stability of the walls of continuous beams given in "The standards and engineering requisites in the design of steel constructions" (NiTU 121-55) are checked with a more precise method of calculation [B. M. Broude, "Boundary conditions of steel beams," Moscow, Gosstroiizdat, 1953]. It is es-

tablished that calculations in accordance with NiTU 121-55 in a series of cases gave significantly lower figures for the critical load. In order to ease the burden of calculation a recommendation is made to use the tables and diagrams compiled by the author. The low standard of accuracy obtained in the results when using the diagrams has to be mentioned; this was due to the necessity of employing other than single-stage graphic interpolation.

B. M. Broude

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**138. Shesterikov, S. A., The question of stability in the presence of creep** (in Russian), Avtorefer. Diss. Kand. Fiz.-Matem. Nauk, MGU, Moscow, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5835.

**139. Mulin, S. M., Stability of a plane form of deflection of an I-beam of stepped-variable section** (in Russian), *Sb. Nauchn. Trudi Tomskii Elektromekhan. In-ta Inzh. Zh.-d. Transp.* **23,** 101–113, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5915.

The stability of the beam described in the title is investigated by the matrix method [see A. F. Smirnov, "Static and dynamic stability of constructions," Transzheldorizdat, 1947]. An example is given for the calculations for the critical load.

V. F. Lukovnikov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**140. Burtchak, G. P., The stability of the two-dimensional form of bending of two double-tee beams connected by elastic transverse and longitudinal links** (in Russian), *Trudi Mosk. In-ta Inzh. Zh.-d. Transp.* no. 92 (11), 49–73, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2238.

The lattice bars of the connection are assumed to be hinged to the beams in the plane of the lattice, and rigidly connected in the direction perpendicular thereto. Differential equations are derived for the rigidity of the structure, and approximately integrated by the Bubnov-Galerkin method for the case of hinged support of beams attached at their ends by diaphragms rigid in their own plane and flexible in the plane perpendicular thereto. Different loading cases of the system along the axis of one of the beams are investigated.

V. A. Mar'in

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**141. Malyutin, I. S., On buckling of a column beyond the elastic range** (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 12, 43–46, Dec. 1957.

After a brief account of the former papers on an elastic buckling of a straight bar written in the years 1946–1956 the problem is solved taking secondary plastic strain into consideration. The bar in question is a rectangular bar simply supported at two points, it being assumed that the material is subjected to linear strain-hardening.

The equation determining the boundaries of the region of secondary plastic strain together with another equation valid for both the elastic-plastic region and that of secondary plastic strain constitute a system of two equations for solving the problem. To solve this system of equations an approximate method is used based on the assumption of a certain shape of the deflection curve, the equations being applied to the middle point of the bar. The results are given in the form of graphs.

W. Wierzbicki, Poland

**142. Kozak, J., Plastic buckling of mild steel rods** (in Czechoslovakian), *Stavebnicky Casopis* **5,** 5, 324–336, 1957.

**143. Yoshiki, M., and Yamamoto, Y., Buckling of rectangular plates compressed beyond elastic limits** (in English), 9th Congrès. Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 70–82.

Paper contains a new theory based on the Prandtl-Reuss flow theory. When tangent modulus sharply decreases at stresses above tangent modulus stress, authors find that this stress is a good approximation to the maximum stress. When that is not the case it is shown that the reduced modulus stress can be used as a good approximation to the maximum stress. In both cases approximations are on the safe side.

Theory is supported by a series of buckling tests on plates of aluminum, high-tensile and mild steel in uniaxial compression, all simply supported along all four edges. Experiments show a good agreement with theory. Buckling stresses are found to be far below values predicted by Pearson whose predictions also are based on the Prandtl-Reuss theory, and somewhat higher than values predicted by Stowell, based on a deformation-type theory of Hencky.

F. I. Niordson, Denmark

**144. Emslie, Betty, Some values of the reduction factor for plastic buckling of plates in shear,** Coll. Aero. Cranfield, Note no. 90, 12 pp., Jan. 1959.

Paper contains approximate solutions of equation for plastic shear buckling as given by W. S. Hemp [Coll. Aero., Cranfield, Note no. 64, 1957]. The plasticity reduction factor, defined as the ratio between the plastic buckling stress and the elastic buckling stress, is calculated for the cases of an infinite plate and a square plate. Comparisons with experimental data seem to favor total strain theory rather than incremental theory as applied by author.

J. Hult, Sweden

**145. Barg, Y. A., Stability of thin rectangular plates** (in Ukrainian), *Prikl. Mekh.* **5,** 1, 83–91, 1959.

The stability of thin rectangular plates uniformly compressed in the $x$-direction for a different combination of boundary conditions on the edges of the plate is considered. Author combines a simply supported edge with a clamped one and obtains nine cases of stability. A simple approximate equation for the determination of a parameter $k$ for each case is derived, a table of $k$ being given for different ratios of the sides of the plate ranging from 0.2, 0.3, 0.5, 1.0, 1.5, 2.5, 4.0, and $\infty$.

Author used the Bubnov-Galerkin method with one and two unknown coefficients.

The bibliography contains five books but author does not refer to works published in American, English and Russian magazines where some of the above cases are considered and simple equations are given.

P. Shuleshko, Australia

**146. Bogdanoff, J. L., Goldberg, J. E., and Helms, H. E., Lateral buckling of rimmed rotating discs,** Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 253–257.

Two methods are presented for predicting whether or not a given radial temperature gradient will cause lateral buckling of a rimmed disk at a specified rotational speed. The web portion of the disk need not be uniform, but the assumptions of classical plate theory are used throughout the web. The first method assumes that classical plate theory is valid to the edge of the disk. The second method, applicable when the rim is thick, uses appropriate ring equations for the rim.

The plate equations are written in a form which avoids the difficulties encountered in applying the usual equation to numerical integration of nonuniform disks.

From authors' summary by B. G. Johnston, USA

## Vibrations of Solids

(See also Revs. 35, 169, 254, 406)

**147. Yushchenko, A. A., Longitudinal oscillations of a string with variable mass at the end** (in Russian), *Ukrain. Mat. Zh.* **8,** 4, 460–462, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 103.

Numerical results obtained from a small electronic computer are given of a calculation of a system of two second-order equations with variable coefficients describing oscillations of an elastic and elastic-tough string of constant length with a linearly variable mass at the end; the equations have been deduced formerly by the author [*Dopovidi Akad. Nauk, USSR*, no. 6, 529–532, 1955; *Dopovidi Akad. Nauk, USSR*, no. 3, 235–237, 1956].

G. N. Savin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**148. Crandall, S. H., Complementary extremum principles for dynamics** (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **5,** 80–87.

This paper exhibits the duality between Hamilton's and Toupin's extremum principles, and derives differential equations and boundary conditions for the motion of a beam compressed longitudinally and vibrating transversely, and for the motion of a thin rectangular beam including the effects of shear and rotary inertia. The equations are not solved, but are shown to be equivalent to those obtained by other methods. P. G. Kirmser, USA

**149. Tchkuasseli, The constrained vibrations of a beam of variable rigidity** (in Russian), *Trudî Gruz. Politekhn. In-ta* no. 6, (47), 47–52, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2110.

The Bubnov-Galerkin method is applied to the solution of problems on the constrained vibrations of beams of variable rigidity. The values of the dynamic displacements are obtained for the case of constrained vibration by the action of a concentrated disturbing force applied to the center of the span, as well as by a uniformly distributed perturbing force. The solution is presented for several variants of the change in rigidity of the beam, both for freely supported and for built-in ends. V. F. Karavanov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**150. Wnuk, M., and Zyczkowski, M., Application of the Puwein formula to the theory of buckling** (in English), *Arch. Mech. Stos.* **9,** 3, 293–300, 1957.

By analogy with an empirical formula of Puwein for the period of large oscillations of a mathematical pendulum, an empirical formula for the large end deflection of a buckled cantilever beam in the elastic range is shown to be in good agreement with the exact expression for the deflection obtained by elliptic integrals, and to be better approximated than other proposed formulas.

M. G. Salvadori, USA

**151. Bisplinghoff, R. L., and Pian, T. H. H., On the vibrations of thermally buckled bars and plates** (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 307–318.

Solutions are presented for the free vibrations of buckled rectangular plates of infinite and of finite length. The latter solutions are based upon an extension of Marguerre's theory for rectangular plates in longitudinal compression. Emphasis is placed on the influence of the lowest buckling mode on the modes and frequencies of vibration. Finally, experimental investigations of the forced and free vibrations are described, and the results of these investigations are compared with the theoretical conclusions.

From authors' summary by H. J. Plass, USA

**152. Mindlin, R. D., Vibrations of an infinite, elastic plate at its cut-off frequencies,** Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 225–226.

Paper draws attention to the existence of modes of vibration of plane waves in a plate in addition to the simple "thickness-modes" noted by Lamb [*Proc. Roy. Soc. Lond.* (*A*) **93,** 114–128]. The new modes are mixed in character, but have the same frequency spectrum as those of Lamb. W. S. Hemp, England

**153. Pignedoli, A., On the vibrations of an elastic plate with an elliptic embedded edge** (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 300–306.

Free vibration of thin flat plate. The problem is at first mathematically defined into Cartesian coordinates $x$ and $y$ and is reduced into two coupled partial differential equations of the second order. Using elliptic coordinates $\xi$ and $\eta$, where $x = c \cosh \xi \cos \eta$ and $y = c \sinh \xi \sin \eta$, and introducing $\rho = \exp \xi$ the problem is transformed into two new partial differential equations of the same order, the solutions of which are epicycloidal transcendental functions, earlier developed by Agostinelli.

The solution is given mathematically and does not contain any numerical values. S. T. A. Odman, Sweden

**154. Yu, Y.-Y., Dynamic equations of Donnell type for cylindrical shells with application to vibration problems** (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 261–278.

Earlier paper [AMR **9** (1956), Rev. 2450], in which dynamic equations were derived similar to Donnell's static buckling equations, is extended to cover the derivation of two sets of equations similar to those of Flügge, one set including the effects of transverse shear and rotational inertia and the other not. Applications of the last set are given in the second part of the paper where shells with free, clamped, and flexibly supported edges are solved by substitution of appropriate wave forms.

M. Botman, Canada

**155. Khvingiya, M. V., Transverse vibrations and stability of wound cylindrical springs with clamped ends** (in Russian), *Trudî Gruz. Politekhn. In-ta* no. 7 (98), 137–144, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6094.

The solution of the problem is obtained by bringing the spring to the shape of an equivalent bar by the known method ["Bases of modern methods of calculation for strength in machine construction," Mashgiz, 1952, ch. VII, § 3]. When deducing the basic differential equation for the spring's vibrations author allows errors to appear. Particular mention should be made of the inaccuracies in Eqs. [1.5] and [1.6] and Eq. [2.3] following them. Author's reference to work by Timoshenko appears unjustified as Timoshenko's equation differs materially from that used by the author. In consequence, the formulas obtained for the vibration frequencies are also wrong. In the particular case, the dynamic terms causing quiescence in the spring vanish. As a result the correct values for the critical forces are obtained, which are also in agreement with known solutions. V. L. Biderman

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**156. Conway, H. D., Some special solutions for the flexural vibration of discs of varying thickness** (in English), *Ing.-Arch.* **26,** 6, 408–410, Dec. 1958.

Author investigates the frequencies of axisymmetrical vibration of disks whose flexural rigidity varies as a power function of disk radius. For a number of positive values of the power exponent and corresponding values of Poisson's ratio, some particular solutions are given in terms of Bessel functions. Also numerical results are presented for a plate with edge-clamping.

Reviewer agrees with author that the exact solutions presented are of limited practical utility. Nevertheless, these exact solutions can be used as standards to measure the accuracy of approximate techniques. R. B. Grant, USA

**157. Kumai, T., Added mass moment of inertia induced by torsional vibration of ships,** *European Shipbldg.* **7,** 6, 147–153, 1958.

Author applies two-dimensional analysis to provide an estimate of the added mass-moment-of-inertia generated by the torsional vibratory motion of ships. Ship sections are replaced by infinitely

long cylinders or prisms having ship-like forms as employed by F. M. Lewis and Prohaska. The method entails the cutting of the ship into strips and the resulting added mass is obtained by integrating the local coefficient of added mass $C$ over the length of the ship. Account is taken of the effect of the location of the center of rotation of each section in the determination of $C$. No three-dimensional flow corrections are made. Comparison of theory with experiments conducted with a prismatic body show remarkably good agreement. Local values of $C$ deviate by about 10% from the measured values over the parallel middle body of a tanker form. An approximate formula for quick application by designers is given. It is shown that the natural torsional frequencies for a tanker vary widely with loading and distribution of loading. It is concluded that an effective means of avoiding torsional criticals is to alter the athwartship loading in the light condition by use of longitudinal bulkheads. J. P. Breslin, USA

**158. La Tegola, A., Periods of vibrations of a structure in the presence of axial forces** (in Italian), *G. Gen. Civ.* **96**, 6, 401–408, June 1958.

Paper is a brief theoretical study of the periods of vibration of straight rods having various elastic end constraints and applied axial forces. Several tables and charts containing calculated results are presented. W. H. Hoppmann, II, USA

**159. Romualdi, J. P., D'Appolonia, E., and Stelson, T. E., Dynamic response of floating bridges to transient loads,** Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 227–232.

Authors present an analysis of the transient response to moving loads of floating bridges of one, two, three and five floating ponton supports. The structures are replaced by lumped mass systems and the problem is represented by a system of ordinary differential equations. These equations include nonlinear terms because the virtual mass of the pontoon is not a constant but varies linearly with its displacement. The solution of the problem is obtained by the application of an electronic analog computer.

Authors present the result in terms of an impact factor defined by the ratio of the maximum dynamic displacement to the maximum static displacement. The effects of damping, mass of moving load and virtual mass on this impact factor are investigated. The analytical solutions are verified by experiments using a scaled model in the laboratory.

Authors conclude that the virtual mass has a significant effect on the transient response of floating bridges. The effect is more pronounced than that of viscous damping. They also find that for a single pontoon bridge, the change in the ratio of the mass of the moving load to the mass of the bridge does not change the impact factor. It merely causes the maximum displacement to occur at a different speed of crossing. T. H. H. Pian, USA

**160. Rotenberg, R. V., Transient vibrations of an automobile** (in Russian), *Avtomob. i Trakt. Prom-st'* no. 8, 14–20, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6320.

The problem is solved in a linear set-up applicable to a two-mass vibrating system with damping proportional to the velocity. The disturbing force originates in the car's movement over an uneven road surface of sinusoidal profile; the vibrations of the front and rear parts of the chassis are assumed to be independent of each other. An analysis is made of the change of position of the wheels, of the change of position of the vehicle and its acceleration in relation to the velocity of the motion and the magnitude of the damping; the transient vibrations are compared with the steady vibrations. It is noted that in the narrow zone of low frequency resonance the changes of position and the acceleration of the vehicle due to periodic unevennesses of the track are greater than when due to a single unevenness. In the neighborhood of high frequency resonance they attain equality, both in transient as well as in stationary vibration. In the wide zone between the above resonances and in the zone of hyperfrequency resonance the passage over a single unevenness is accompanied by changes of position and accelerations, the maximum values of which are greater than those for periodic unevennesses. K. S. Kolesnikov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**161. Polachek, H., Calculation of transient excitation of ship hulls by finite difference methods,** David W. Taylor Mod. Basin Rep. 1120, 56 pp., July 1957.

The transient response of a nonuniform beam, including shear deformation and rotary inertia effects, is calculated by finite-difference solution of the governing partial differential equations. The free-free beam, intended to represent a ship hull, is divided into 20 segments lengthwise, and allowance is made for an arbitrary concentrated force acting on each after a certain initial instant. A test for stability of the numerical procedure is applied to establish the maximum permissible time interval.

Data are supplied regarding the programming of the method on a digital computer of the UNIVAC type. Two sample calculations are presented of the response of a typical hull to large impulsive forces at the bow and amidship. H. Ashley, USA

## Wave Motion and Impact in Solids

(See also Revs. 4, 152, 161, 473)

**162. Sveklo, V. A., On the theory of impacts of cylinders,** *Soviet Phys.-Doklady* **3**, 3, 530–534, Jan. 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **120**, 1, 47–50, May–June 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

An approximate theory of the impact of arbitrary cylindrical bodies, for the case of initial contact of order $n > 1$, has been presented in this paper. The method consists of the vibratory relations set up by the impact in the sections of the disks which are in contact. In the case of the contact of the $n$-order, the same conclusions have been obtained as in the three-dimensional. The problem is based on the Hertz hypothesis. For $n = 1$, the theory has no meaning. M. M. Stanisic, USA

**163. Gran Olsson, R., Transverse waves in rods and plates under impact load** (in German), *Öst. Ing.-Arch.* **12**, 1/2, 93–95, Nov. 1958.

Paper contains an extension to comment on the article of the same title by M. A. Dengler [*Öst-Ing. Arch.* **10**, 1, 39–66, 1956; AMR **9** (1956), Rev. 3187]. It is shown, briefly, that the range of the introduced parameters used for calculations should be changed in order to obtain results more suited to practically occurring cases. V. Kopriva, Czechoslovakia

**164. Michaels, J. E., Thermally induced elastic wave propagation in slender bars,** Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 209–213.

The one-dimensional wave equation modified to include the thermoelastic effect is solved using Fourier transforms for bars of semi-infinite and finite length assuming the ends to be stress-free. A numerical calculation made on the basis of a hypothetical temperature distribution indicates that extreme thermal shock may be a contributing factor in structure failure.

J. Fulton, Scotland

**165. Miklowitz, J., On the use of approximate theories of an elastic rod in problems of longitudinal impact,** Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 215–224.

Approximate solutions for the longitudinal impact and pressure shock problems in a semi-infinite circular rod, valid for large times, are derived in accord with the Mindlin-Hermann theory. The solutions are shown to be equivalent. Further they are in basic agreement with that Skalak derived recently for the longitudinal impact problem from the linear equations of elasticity. It is shown that the differences lie in a wave-front discontinuity, and the adjustment of a correction factor, properties of the approximate theory solutions.

Comparison of radial and axial strains with experiment is made and good agreement is found, particularly in the case of axial strain. Comparison is also made with related results from the Love and Bishop-Sutton approximate theories. Overall properties considered, the Mindlin-Hermann theory offers the best approximate theory representation of the rod disturbance for large times.

From author's summary by K. Kasahara, Japan

**166. Volterra, E., On the dispersion of waves in elastic bars** (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7**, 285–292.

Author briefly compares phase and group velocity dispersion curves for lowest mode longitudinal waves in bars of rectangular cross section. Results derived from several theories are shown, in particular the author's own "Method of internal constraints" [*Ing. Arch.* **23**, 6, 410–420, 1955].

Reviewer notes several features resulting from imposed brevity. Although dispersion curves vary widely in shape, no comment is made regarding significance or reasons for this. At short wavelengths, the velocity should approach that of Rayleigh waves. It is not indicated whether any of the cited theories give this result. Quantities such as $L$ (wavelength?) are not defined.

R. Lyon, USA

**167. Jahsman, W. E., Propagation of abrupt circular wave fronts in elastic sheets and plates,** Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 195–202.

The equations of motion of a homogeneous isotropic elastic sheet, as derived by Kane and Mindlin, and those for a plate, as derived independently by Uflyand and Mindlin, are analyzed by the method of characteristics for the case of an in-plane ring-load suddenly applied. It is shown that in the case of the sheet there are two velocities of propagation, while in the case of a plate there are three. The variation with radial distance of the magnitudes at the wave fronts of the dependent variables in the equations of motion are investigated and found to diminish as $r^{-1/2}$ as the wave fronts progress outward.

J. Fulton, Scotland

**Book—168. Oniashvili, O. D., Some dynamical problems in the theory of shells** (in Russian), Moscow, Akad. Nauk SSSR, 1957, 195 pp., illus. 9r. 35k; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5774.

Book is devoted to the application of the theory of shells and of prismatic systems evolved by V. Z. Vlasov to some problems of small vibrations, stability and statics. The book consists of seven chapters. The first chapter contains a short exposition of Vlasov's technical moment theory. In the second chapter an investigation is made of the small natural vibrations of a sloping shell with constant curves, supported on a rectangular contour, and also of a sloping spherical segment clamped along the contour. By means of several numerical examples the evaluation is illustrated of the influence of the tangential inertia forces and the "lifting capacity" of the shell. The third chapter deals with the application of the Bubnov-Galerkin variational method to problems in statics and principally to the small natural vibrations of sloping shells. The equations of the "mixed" method form the opening part of this chapter (expressions conveyed through the stress functions and normal deflections) while the approximating functions combine out of the corresponding "girder" functions. A number of numerical examples are given for the determination of the natural vibrations of rectangular plates and sloping shells in various combinations of boundary conditions.

In the fourth chapter the author examines the problem of the dynamic strength of a sloping shell, under the action of periodic forces, delimiting the problem by the simplest of linear arrangements leading to Mat'e's equation. At this point also the results are given of some calculations relating to the stability in the "small" sloping cylindrical shell. The fifth chapter, with the heading "nonlinear problems", contains a numerical evaluation of the influence of nonlinear terms on static bending, the frequencies of natural vibrations and critical forces for concrete examples of sloping shells with different angles of slope. In the sixth chapter cases are investigated of the loading of shells with static horizontal forces; this is done with consideration for the elementary methods of calculations for installations liable to seismic disturbances. Together with the examination of sloping shells an inquiry is made of cylindrical folded constructions (within the framework of Vlasov's theory). The results of field tests on ferroconcrete coverings are given as the subject matter of the last chapter.

V. V. Bolotin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**169. Baker, W. E., and Allen, F. J., The response of elastic spherical shells to spherically symmetric internal blast loading,** Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 79–87.

The elastic response of a thick spherical shell to a transient pressure applied uniformly over the inner surface is derived. The method utilizes an auxiliary displacement variable to transfer a nonhomogeneity in the boundary equation to the differential equation. The solution is in the form of an infinite series of time-dependent contributions from all the radial vibration modes plus a term proportional to the instantaneously applied pressure. A more explicit solution is given for the case where the applied pressure is a triangular function of the time, and an approximation is separately derived for a thin shell where only a single radial mode exists.

Theory is shown to be in rough agreement with experimental measurement of strain on outer surface of hollow sphere whose inner surface is exposed to blast pressure from small explosive charge. However, the experimental results are obviously insensitive to most of the details of the theory.

G. Chertock, USA

**170. Usami, T., Elastic waves in a homogeneous and isotropic medium generated from a spheroidal origin,** *Geophys. Mag., Tokyo* **29**, 1, 1–9, Nov. 1958.

It is well known that, upon introducing a scalar and a vector displacement potential, the equation of motion of an isotropic elastic medium can be decomposed into two separate wave equations; one for the propagation of dilatational and one for distortional displacements respectively. Based on the difference in the propagation speeds of these two types of waves, this principle has been successfully used in locating seismic wave origins.

In the present study author expresses the equations of motion, i.e., the wave equations for scalar and for vector potentials, in the following two different spheroidal coordinate systems: (1) oblate, (2) prolate. The solutions are obtained by standard technique of separation of variables, with the results expressed in the form of an infinite series of spheroidal-harmonic product terms. The solutions are suitable for studying wave propagations in an isotropic, elastic medium of infinite extent, subjected to arbitrary initial conditions over oblate or prolate spheroidal boundaries.

H. S. Tan, USA

**171. Usami, T., Elastic waves generated from a spheroidal cavity whose wall is subjected to normal stress of harmonic type,** *Geophys. Mag., Tokyo* **29**, 1, 11–36, Nov. 1958.

An earlier study is continued into dilatational and distortional wave propagations in an isotropic, elastic medium originated from an "oblate" spheroidal cavity, (previous case, prolate cavity), subjected to periodic normal cavity pressure. Solutions of respective displacements were obtained in form of infinite series, consisting of product terms of spheroidal functions, with prescribed periodicity.

It was noted that the ellipticity of cavity geometry and the ratio of wavelength to cavity dimension are the two controlling parameters over propagation pattern. Azimuthal distributions of radial and tangential components of displacements, at large distance from origin, were tabulated and plotted for several values of ellipticity and wavelengths. However, due to paucity of cases computed, definitive conclusions on the parametric dependence of distribution pattern can not be readily drawn.

Some corrections to earlier calculations are appended in an "Errata." H. S. Tan, USA

**172. Bollenrath, F., and Troost, A., The propagation of plastic waves under axial shock** (in German), *Z. Flugwiss.* **6**, 7, 193–198, July 1958.

Propagation of plastic waves in long rods under axial tension or compression is considered according to current theory. Limits of this theory are discussed and possibilities for extensions are given.

From authors' summary by A. Kochendorfer, Germany

**173. Thomas, T. Y., Plastic flow and fracture in solids,** *J. Math. Mech.* **7**, 3, 291–322, May 1958.

Analysis is based on concept that fracture occurs in discontinuities at elastic-plastic boundary and is the same for compression and tension. But ductile materials fracture, on any scale large enough to be treated by continuum mechanics, only after strains much larger than elastic, and, since pressure has a large effect, fracture in compression and tension cannot be given by same formulae [Nadai, "Theory of flow and fracture of solids," McGraw Hill, 1950; Bridgman, AMR **6** (1953), Rev. 462]. Near brittle transition temperature where cracks in Luders bands are found [Hahn, Averbach, Owen, and Cohen, Pap. no. 4, Conference on Fracture, Nat. Acad. Sci., 1959], "microcracks are initiated after discontinuous yielding is locally complete, and not as a direct consequence of the Luders strain." Only experimental evidence referred to by author [Nadai, op. cit. p. 346] deals with fracture of porcelain, which is hardly a plastic material to which the Prandtl-Reuss equations may be applied!

Since author's basic assumptions regarding fracture are unrealistic, reviewer believes subsequent analysis to be of value chiefly as study of allowable discontinuities in a non-strain-hardening, elastic-plastic material. F. A. McClintock, USA

**Book—174. Rogers, G. L., An introduction to the dynamics of framed structures,** New York, John Wiley & Sons, Inc., 1959, xv + 355 pp. $10.25.

This text is an introductory volume written particularly for the structural design engineer and, to the best of the reviewer's knowledge, is one of the first books at this level and for this audience. The chapter titles provide a ready index to the contents: 1. Dynamic disturbances; 2. Structures with one degree of freedom; 3. Structures with two degrees of freedom; 4. Structures with many degrees of freedom; 5. Free vibrations of slender, elastic beams; 6. Inelastic beams and corrections to the theory of elastic beams; 7. Beams subjected to arbitrary disturbances; 8. Continuous beams; 9. Rigid frames; 10. Floor systems; 11. Energy methods in structural dynamics.

The treatment is largely based on modal methods, supplemented by a rather good discussion on the practical application of phase-plane methods to single-degree-of-freedom systems (Chapter 2). The basic content, except possibly for Chapters 8–10, is essentially that of almost any modern book on the theory of vibrations, but is distinguished by (1) the emphasis on configurations of particular interest to structural designers (i.e., multistory buildings, continuous beams, bridges) and (2) the large number of completely worked out numerical examples. For these reasons, reviewer believes that the book will prove of considerable value to design engineers who encounter dynamical problems only infrequently or are encountering them for the first time.

It must be mentioned, on the negative side, that reviewer found the treatment to be somewhat uneven. For example, Chapter 6 purports to treat inelastic beams and corrections to the theory of elastic beams, while in fact the corrections are almost entirely to frequencies and the inelastic problem is mentioned in only one brief paragraph (the treatment of inelastic problems of single-degree-of-freedom systems in Chapter 2 is, on the other hand, fairly well done). Also, Chapter 11 on energy methods is extremely brief and devoid of example, in striking contrast to the remainder of the book; it is unfortunate that the author did not give a treatment of these methods in keeping with their importance to designers.

The book is pleasant and easy to read and is, in general, carefully done and well gotten up. It will probably be well received.

H. N. Abramson, USA

**175. Tun, K., Reflection and refraction of a plane longitudinal elastic wave originating at the bottom of the ocean** (in Russian), *Vestn. Moscow In-ta, Ser. Matem., Mekh., Astron., Fiz., Khimii* no. 1, 22–34, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6699.

An investigation is carried out of an isotropic and homogeneous elastic semiplane, covered with a layer of a heavy ideal liquid, and the character is examined of the propagation of the plane waves in the elastic medium and in the liquid. Basis for the success of the investigation appears to be the equations for the velocity potential of sound waves $\varphi$ in the heavy liquid and the equations for the potentials of change of position of $\Phi$ and $\Psi$ in the elastic medium with corresponding boundary conditions operating on the free surface of the liquid and on the boundary of the division between the elastic medium and the liquid. The influence of ponderability is taken into account by means of two parameters $\xi = gH/c^2$ and $\zeta = gH/\nu^2$, which, for actual cases, appear to be of small magnitude. Here $g$ is the acceleration of the force of gravity, $H$ the thickness of the liquid layer, $c$ the velocity of the spreading of sound in the liquid and $\nu$ the velocity of the propagation of the longitudinal elastic waves. To start with, general correlations are established for the sinusoidal waves, and on this basis an explanation is given for the character of the fracture and reflection of the longitudinal and elastic waves. Then the superposition of the sinusoidal curves is taken in hand and a detailed examination is carried out of the propagation of the disturbances, characterizing the $\delta$-functions for two cases $\nu > c$ and $\nu < c$. At this point a study is made of a wave on a free surface, which comes into being as the result of a momentary reflection and refraction of sound waves, and the propagation of excitations from the liquid to the elastic medium. M. D. Khaskind

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**176. Ang, D. D., and Williams, M. L., The dynamic stress field due to an extensional dislocation,** Proc. 4th Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Univ. of Texas Press, 1959, 36–52.

Paper treats wave patterns due to plane dislocation moving in infinite elastic medium. Range of velocities from zero to infinity is considered, and there is a fundamental difference in the wave patterns for dislocation velocities below the velocities of sound and those greater than either or both of these. Problem is formulated in terms of Fourier integral equations and solved in closed form. From authors' summary by L. E. Malvern, USA

**177. Goodier, J. N., Jahsman, W. E., and Ripperger, E. A., An experimental surface-wave method for recording force-time curves in elastic impacts,** *J. Appl. Mech. (Trans. ASME,* Series E)**26,** 1, 3–7, Mar. 1959.

Paper presents a method for deducing force time curves of impacts on the plane surface of a block from oscilloscope records of Rayleigh surface waves. Dispersive effects, which make Hopkinson bar measurements inapplicable to impacts of short duration, are thus avoided. Method is based on experimentally verified aspects of Lamb's asymptotic solutions. Results of the application of the method are compared with Hertz's theory and a direct measurement. R. A. Eubanks, USA

## Soil Mechanics: Fundamental

(See also Revs. 15, 277, 278)

**178. Chadwick, P., The quasi-static expansion of a spherical cavity in metals and ideal soils,** *Quart. J. Mech. Appl. Math.* **12,** 1, 52–71, Feb. 1959.

An infinite medium of ideal soil contains a single spherical cavity within which a slowly increasing pressure is applied. The analysis of stress in the resulting plastic-elastic system, in conjunction with the flow rule associated with the Coulomb law of failure, leads to an expression for the radial displacement of the soil. It is found, in particular, that the radius of the cavity increases indefinitely as the applied pressure approaches a finite limiting value. Since the work done at the cavity wall also increases without bound this pressure cannot be attained physically.

When the angle of shearing resistance of the soil is zero the Coulomb law and flow rule are, under conditions of radial symmetry, formally identical to the yield criteria of Tresca and von Mises and their associated flow rules. A special case of the analysis is hence appropriate to the expansion of a spherical cavity in a non-hardening metal. Calculations have been carried out for copper and a comparison is made with numerical results obtained from an alternative solution due to Hill. It is shown that the inclusion of work-hardening does not alter the behavior of the medium qualitatively.

If, on the completion of loading, the pressure exceeds a certain limit, further plastic flow takes place round the cavity on unloading. Equations are obtained from which can be calculated the residual stresses and displacement at any stage of the unloading process.

From author's summary by S. R. Faris, USA

**179. Tchakhvadze, G. Z., An investigation of the shear resistance of loess soils of disintegrated structure** (in Russian), *Trudi Sredneaz. N.-i. In-ta Irrigatsii* no. 82, 35–53, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2203.

The results are described of investigations made to determine the influence of various experimental methods on the change in shear resistance of loess soils with a disintegrated structure and varying screen analysis. The resistance values of the soil samples are determined by direct shearing in the conditions of complete and incomplete compaction under load. In addition, tests were made on the separate determination of the cohesion forces by shearing in the absence of normal pressure, and by the method of rupture of the sample. The influence of loading levels and rate of deformation in shear was also studied. As a result of numerous experiments, the following conclusions are made: (1) The relationship of the shear in the change of density is conditioned by the moisture content of the sample at different stages of the test; (2) It is preferable to use test samples of ovoid cross section, to the advantage of the conditions of deformation and a better behavior of the sample under load. At the same time, a number of unfavorable phenomena have been identified, associated with determination of the shear resistance of a soil with previous supercompaction of the sample. It is recommended to conduct the tests in conditions of complete or incomplete compaction of the sample under load. Z. V. Maslova

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**180. Evdokimov, P. D., Differential equations of the compressed state and deformations of soils** (in Russian), *Izv. Vses. N.-i. In-ta Gidrotekhn.* **57,** 55–70, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 1032.

The described experimental investigations show that unskilled calculations of values of the mechanical characteristics of soil—such as the angle of internal friction $\varphi$ and of the adherence force $c$—depend considerably on the methods used. Thus, for example, the values for angle $\varphi$ calculated by different methods for the same dry sand are as follows: 32–35° by the method of a cut-away sample, 40–43° by the 3-axis compression method, and 26–28° by the stamp-slide method. This large divergency of results can be explained by the fact that each method disturbs different active areas of the investigated ground. Apart from that, the bigger the zone of the active deformation, the smaller are the values obtained for the Coulomb parameters of the linear relations $\varphi$ and $c$.

A theoretical determination is examined of the stress-strain state of soil in conditions of ultimate equilibrium. The equation for tangential stresses is given, according to Boussinesq, in the form $\tau = \mu(du/dn)\sigma$, where $\mu$ is generalized coefficient of friction, $u$ displacement, $n$ normal line to the examined surface area, $\sigma$ mean normal stress at the given point of the ground. The system of three nonlinear differential equations of the second order is deduced to determine the unknown functions $\sigma$ and displacement $u$, $v$ and $w$ (analogous to the Navier-Stokes equations). The supplementary equation is obtained from the condition of continuity. Problem of integration of the system of equations for the subultimate conditions is not considered. G. A. Geniev

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**181. Hammad, H. Y., Drainage of a soil layer of finite thickness by means of a system of covered drains,** Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 189–192.

Drainage through a porous soil cover to a series of parallel drains is investigated by examining the suitable solution of Laplace equations. The analysis is essentially equivalent to the corresponding problem in the conduction of heat from a flat surface to a series of parallel line sinks. Slight differences arise due to the occurrence of a free water surface in the soil.

N. A. Hall, USA

**182. Penman, A. D. M., Shear strength and pore pressures,** Proc. Midland Soil Mech. Found. Engng. Soc. **1,** Pap. no. 5, 85–96, May 1957.

The relation between the effective stress and the pore pressure in a soil is discussed and it is seen that clay acts as a $\phi = 0$ material only in relation to total stresses and when it is undrained. Even sand will behave as a $\phi = 0$ material if it is saturated and completely undrained. Increase in effective stress causes an increase in shear strength with both materials. Both drained and undrained tests are discussed.

Effective stresses in the ground can be obtained from a knowledge of the pore pressures, and several types of piezometer are described. From author's summary

## Soil Mechanics: Applied

(See also Revs. 114, 260)

**Book—183. Trumbachev, V. F., Distribution of stresses around rock workings** (in Russian), Ugletekhizdat, 1956, 126 pp. 5r.40k; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4630.

The stressed condition is determined in a rocky "massiv" weakened by workings of different forms. The stressed condition is investigated around preparatory workings, clearing up workings in layers falling down slopes and clearing up workings in layers falling steeply. The stress determinations were carried out by means of an optical method on models made from "Igdamtine." In all these cases only the maximum tangential stresses were determined, the determination of the principal normal stresses was only done in one case. Different pitprop arrangements were examined, and their interaction with the lateral rock strata. The pitprop models were absolutely rigid in relation to the models of lateral rock strata, a state of affairs not met with in natural conditions. Based on the investigations made, some recommendations are put forward for the selection of methods for dealing with pit roofing.

Yu. M. Liberman

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**184. Molykov, I. D., Some questions on the shear of rock strata above underground workings** (in Russian), *Izv. Akad. Nauk KazSSR, Ser. Matem. i Mekhan.* no. 5 (9), 105–108, 1956; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4627.

The process of shear of rock strata above underground workings is viewed as a problem on the dynamic equilibrium of a heavy plastic semispace. Equations are derived for the motion of the special case when the acceleration components are constant on the surface as well as in the whole thickness of the mass of continuous medium being investigated. For this case the system of equations of the motion is reduced to differential equations describing the boundary stressed state of the friable medium.

I. V. Fedorov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**185. Pratussevich, Ya. A., Approximate formulas for the settling of elastic foundations under certain types of loading** (in Russian), *Trudi Mosk. In-ta Inzh. Zh.-d. Transp.* no. 92/11, 153–168, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2185.

Based on the Boussinesq formula an analytical expression is set up for the vertical displacements along the longitudinal central axis of a rectangle of length $l$ and width $b$, situated on the surface of an elastic semi-space. It is assumed that the vertical loading, distributed over this rectangle, is invariable in the transverse direction, while in the longitudinal direction it is either constant or varying according to a linear law, or according to a square parabolic law. Author maintains that the resulting equations for the settling displacement can be approximated by simpler equations, using the following method. Let the load per unit length $p(x)$ be distributed along a straight line of the length $l$ with the coordinate origin at one end of this straight line. In such case, the equation of the settling movements (in the conventional notation), will be

$$w = \frac{1-\nu_0^2}{\pi E_0}\left[\int_0^x \frac{p(x-t)}{t}\,dt + \int_0^{l-x} \frac{p(x+t)}{t}\,dt\right]$$

giving in every point an infinitely large value of the settling movement. If, in the same formula, we replace the parameter $t$ by $t+\epsilon$, i.e., neglecting the loading values at a distance from the moving point less than $\epsilon$, then the settlement movements will be finite, and determined by equations of simpler form. For a particular ratio of $l/b$ it is possible to select a value of $\epsilon$ at which the loading along the straight line, in the above method, sufficiently closely represents the influence on settling of a continuous load distributed over the area of the foundation. Author claims that this method can be used not only to determine settling movements, but also in the calculation of beams, and even slabs, on elastic supports.

M. I. Gorbunov-Posadov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**186. Pratussevich, Ya. A., The analysis of beams supported on an elastic, isotropic foundation** (in Russian), *Trudi Mosk. In-ta Inzh. Zh.-d. Transp.* no. 92/11, 181–190, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2229.

An examination of the analysis of beams on an elastic, isotropic support under the action of symmetrical and unsymmetrical loads. The law of change of the reactive pressure is stated in the form of a series

$$p = p_0 + \sum_{i=1}^{\infty} p_i \varphi_i$$

where $p_0$ is mean intensity of the reactive pressure due to the load on the beam; $\varphi_i = a_i - \xi^i (1-\xi)^i$, where $a_i$ is so selected that the integrals of the function $\varphi_i$ over the length of the beam are equal to zero. The parameters $p_i$ are determined from the condition of equality of the curvatures of the beam and the line of settlement of the foundation at corresponding points. In the examples given, diagrams of the reactive pressures and bending moments are plotted; for comparison, diagrams are also presented for the pressures obtained by the methods of M. I. Gorbunov-Possadov and B. N. Zhemotchkin.

I. V. Kiseleva

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**187. Chaplin, T. K., Practical examples of bearing capacity calculation,** Proc. Midland Soil Mech. Found. Engng. Soc. **1,** Pap. no. 1, 4–28, Jan. 1957.

The calculation of bearing capacities has hitherto been largely confined to shallow foundations, using the Terzaghi method. In more recent years, methods have been developed by Meyerhof and Skempton for shallow and deep foundations in clay and sand. Most methods have been used in the paper.

Examples are worked out fully for various practical cases in both clay and sand, to show the simple nature of the calculations and to introduce practicing engineers to this new extension of foundation design. These examples have been chosen to bring in the main practical aspects of foundation design.

A revised Table of definitions of consistency is proposed, extending the Code of Practice definitions to cover harder clays.

From author's summary

## Processing of Metals and Other Materials

**188. Wilcox, R. J., and Whitton, P. W., The cold extrusion of metals using lubrication at slow speeds,** *J. Inst. Metals* **87,** 289–293, 1958/59.

Super-pure aluminum has been extruded by the direct and inverted methods using dies of semi-cone angle varying from 30° to 90° and of extrusion ratio varying from 2 : 1 to 150 : 1.

A general equation relating the inverted-extrusion pressure to the semi-die angle and extrusion ratio has been derived empirically by using a mean value of yield stress for each extrusion ratio; this mean value is taken to be that at the logarithmic strain appertaining to the extrusion ratio considered. The general equation so de-

rived is a summary of the individual equations obtained for each particular angle of die and covers a much wider range of conditions than any hitherto presented. Comparison of results for 90° dies with published data obtained under nearly identical conditions shows that extrusion pressures predicted by the equation are accurate to within ± 6% of the experimentally determined pressures for various materials. It is envisaged that the equation will have general application for hot and cold extrusion provided that the appropriate mean yield stress is known accurately.

The pressure for direct extrusion can easily be obtained if the coefficient of friction between billet and container wall is known.

Dead-metal formation and pressure due to redundant work are examined, and the optimum die angle for minimum extrusion pressure is shown to be dependent on the extrusion ratio.

From authors' summary

**189. Morozov, B. A., The application of a polarization-optical method for the study of the processes involved in the rolling mill industry** (in Russian), Rolling mills (8), Moscow, Mashgiz, 1956, 225–247; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7263.

A description is given of the construction of a mill, which makes it possible to follow the milling process by passing polarized light through the operating rollers and the material being rolled. The rollers used for the three-dimensional investigations were prepared from organic glass with phenoplastic insets. The material in the strip to be used was an antimonial lead compound, which gave a sufficiently clear optical picture with a large number of bands and a sufficiently long arc of curvature. In the steady process of rolling, the picture of the bands remains immovable, consequently the photographs of the isochromes and isoclines can be taken in sequence at different angles of rotation of the polarization and the analyzer, without recourse to cinephotography. The measurement of the transverse deformations of the rollers was effected with the aid of special measuring clamps made of organic glass. Experiments were carried out on the cutting of rectangular strips of lead with scissors with parallel blades (made of phenoplastic); also to investigate the process of drawing the lead into wire by means of a drawplate made of organic glass and with an inset of phenoplastic on the meridional section. Optical pictures were obtained which enabled decisions to be taken regarding the stresses in the range of contact of the instrument with the treated material.

G. A. Tulyakov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**190. Tong, K., and Sachs, G., Roll-separating force and minimum thickness of cold-rolled strips,** *J. Mech. Phys. Solids* **6,** 1, 35–46, 1957.

**191. Letner, H. R., Stress effects of abrasive tumbling,** *Trans. Amer. Soc. Metals* **51,** 402–420, 1959.

Tool-steel specimens at four hardness levels were tumbled with aluminous abrasives under a variety of conditions, and the resulting surface stresses were measured. Behavior was observed for three initial stress conditions: stress-free surfaces, ground surfaces, and heat-treated surfaces. Residual stresses induced in initially stress-free steel by tumbling were always compressive at the surface and decreased uniformly to zero at a depth of a few thousandths of an inch. The magnitude and depth of penetration of the stress increased with particle size, but depended very little upon the type of abrasive used. Steel hardness affected both the magnitude and depth of penetration; the maximum compressive stress at the surface increased, and the thickness of the stressed layer decreased with increasing hardness. Tumbling removed initial surface stresses in layers up to a few thousandths of an inch thick, and replaced them with its own characteristic compressive stress. The degree to which this substitution took place also depended upon the size of the abrasive and the hardness of the steel.

From author's summary

**192. Zubov, V. Ya., Testing a spring ribbon for relaxation** (in Russian), *Zavod. Lab.* **22,** 3, 329–331, 1956; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4799.

This is an investigation on the change of stresses of deflection of a spring ribbon, determined by measurements of the radius of curvature of the ribbon, curved along the arc of a circle when the ribbon is being fed into a steel ring and freed after heat treatment.

V. A. Bykov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**193. Matsuyama, T., and Kayaba, T., A study on the electro-spark machining by the alternating current,** *Bull. JSME* **2,** 5, 86–91, Feb. 1959.

A study of the electro-spark machining process by the alternating current in the circuit used by Lazarenko is described. The results of this investigation are as follows: With the alternating current, the machining speed is maximum and in the widest extent of the work-current machining is stable, using a solid brass bar electrode. The larger the condenser capacity is, the wider this extent becomes, and the larger the work-current grows, at which the machining speed is maximum as in the case of direct current. Regardless of the condenser capacity, the electrode consumptions are almost constant under a certain work-current, which is largest when a solid brass bar electrode is used. Under a certain diameter of electrode, machining speed is little affected by it. The clearance between hole and electrode is also little influenced by the work-current, if it is beyond a certain value.

From authors' summary

**194. Chang, T.-m., Shu, U-y., Gau, T.-m., and Kuoh, S.-c., The workability of cast iron with spheroidal graphite** (in English), *Scientia Sinica* **8,** 1, 110–131, Jan. 1959.

In order to determine the workability of cast iron with spheroidal graphite, the following tests have been conducted on this material in the as-cast and annealed condition: tensile tests, compression tests, Charpy impact tests, impact tensile tests, twisting tests, upsetting tests under the drop hammer and small-scaled rolling tests.

Results from these tests show that the best hot-working temperature range of this material varies somewhat with the stress system applied and the speed of working, and in general lies between 700° and 1100°C. Within this temperature range, the maximum amount of working permissible for a single working operation varies considerably with the stress system applied. Under tensile stresses, this maximum amount of working lies between 28 and 57.6%; under predominantly compressive stresses, it lies between 58.5 and 72.9%; while in the small-scaled rolling tests, the maximum reduction in thickness permissible for a single pass lies between 38.6 and 44.3%. The maximum amount of working permissible is also affected by the speed of working, being greater at lower speeds.

Tests on industrial scale show that the upsetting and small-scaled rolling tests give results nearest to those from industrial tests. Charpy impact tests, impact tensile tests, upsetting tests and small-scaled rolling tests show more prominently the best hot-working temperature range than the other tests conducted.

Results of the present research also indicate that cast iron with spheroidal graphite has a higher strength and workability when subjected to compressive stresses than to tensile stresses, and that a brittle temperature range has been recorded between 200° and 650°C which varies with the speed of test. Judging from the variation of the resistance to deformation with the change of temperature and the speed effect, this phenomenon is probably associated with blue brittleness. From authors' summary

**195. Paliwoda, E. J., The machinability of type A leaded steels,** *Trans. Amer. Soc. Metals* **50,** 258–268, 1958.

**196. Okoshi, M., and Sata, T., Friction on relief face of cutting tool,** *Scient. Pap. Inst. Phys. Chem. Res., Japan* **52,** Pap. 1493, 8 pp., Dec. 1958.

Cutting tests on SAE 4140 are described. Contact length between relief and machined surfaces varies. Compressive stress on relief face increases with contact length; shear stress remains constant and equal to that on rake surface.

R. N. Arnold, Scotland

## Fracture (Including Fatigue)

(See also Rev. 173)

**197. Martin, D. E., and Sinclair, G. M., Crack propagation under repeated loading,** Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 595–604.

Tests on sheet 24S-T3 aluminum alloy indicate three distinct phases: nucleation, propagation by fatigue, and fast propagation by creep to fracture. Characteristics of the crack in each of the three stages are discussed and attempts are made to correlate the second phase results with various analytical predictions as to rate of propagation. Authors conclude that rate may not be determined from nominal stress alone and that fair correlation is possible with theoretical stress at crack tip and with parameters associated with Griffith theory. Failure life ranged from $10^3$ to $6 \times 10^5$ cycles and crack lengths from 0.005 to 2.2 inches before failure.

W. E. Cooper, USA

**198. Boyd, G. M., Survey on the problem of brittle fracture** (in French), *Rev. Soudure* **14,** 4, 175–187, 1958.

**199. Scheidegger, A. E., A survey of the mathematics available for describing fracture,** *Can. J. Phys.* **36,** 3, 300–308, Mar. 1958.

**200. Manson, S. S., Succop, G., and Brown, W. F., Jr., The application of time temperature parameters to accelerated creep-rupture testing,** *Trans. Amer. Soc. Metals* **51,** 911–934, 1959.

Authors discuss the validity of different relations, especially the application of time-temperature parameters in developing isothermal creep-rupture curves. The parameter constants and the master curves are determined for a ferritic and austenitic alloy [Timken 17–22 A S and Timken 16-5-6, respectively] over a wide range of stress and temperature with a rupture time range of 1 to 100 hrs. The calculated isothermals, using the parameters proposed by Larson and Miller, Manson and Haferd and by Dorn, are compared with data of conventional stress-rupture tests. The results of the calculations and of the experiments agree very well for the isothermals developed on the basis of the Manson and Haferd relation.

M. Hempel, Germany

**201. Herrmann, G., and Chu, H.-N., Theoretical determination of lifetime of compressed plates at elevated temperatures,** NASA Memo 2-24-59W, 21 pp., Mar. 1959.

A method of determining the lifetime of compressed plates at elevated temperatures is shown. The stress-strain-time curve of the material is represented by a standard linear solid. The effective Young's modulus along the direction of loading is assumed to decrease as the isochronous secant modulus. This is not theoretically justified. The calculated lifetimes of 2024-T3 aluminum alloy plates at 450F are compared with experimental values.

T. H. Lin, USA

**202. Aleksandrov, B. I., Fatigue strength and stress-concentration sensitivity in steel EI-434 at high temperatures** (in Russian), Investigations on heat-resistant alloys, Moscow, Akad. Nauk SSSR, 1956, 60–68; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2409.

The investigation was made on steel EI-434 after tempering and stabilizing at 20, 650, 700, and 750°. The samples tested were both smooth and with circular notches, finished by machining and grinding. The high-temperature tests were made at 10° load cycles. In addition to the fatigue tests, the mechanical properties of the steel and the microstructure of the samples, in the initial state and after cyclic loading, were determined. It has been found that at 20–650°, steel EI-434, after tempering and stabilization, has a high fatigue limit; the conditions of stabilization up to 700° have no great influence on the fatigue strength. The experiments made enable the surface peening of machinery parts of steel EI-434 to be recommended, for increasing the fatigue strength in the points of stress concentration.

A. M. Sinyukov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**203. Merekina, V. V., Methods for plotting diagrams of the true stress at high temperatures** (in Russian), *Zavod. Lab.* **22,** 12, 1491–1492, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2448.

It is proposed to test a series of samples, the first of which is tested to destruction and the remainder to varying stages of deformation. This will enable more accurate plotting of the experimental curve. Curves of the true stress for Alloy BM65-1 are given.

Yu. G. Maksimov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**204. Ginzburg, E. S., Investigation of the structure of the metal in steam pipes after prolonged use at high pressures in electricity generating stations** (in Russian), Strength of metals, Moscow, Akad. Nauk SSSR, 1956, 58–66; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6168.

Results are given of an investigation on the microstructure, mechanical properties, resistance to creep and duration of strength of four steam pipes as described in the title, the "life" having extended to 38–53,000 hours at a working temperature of 490° and a pressure of 100 atm.

From author's summary

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**205. Vassiliev, D. M., Margolin, G. I., and Dianov, S. V., A radiographic investigation of the nature of failure under dynamically applied load** (in Russian), *Zh. Tekh. Fiz.* **26,** 9, 2119–2124, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2354.

An investigation of the microscopic and submicroscopic distortions of the structure of steel samples under impact (dynamic) loading. The samples were tested for impact-bend testing in the range between −190 – −120°; a linear relationship was found between the widening of the spectrum line and the impact toughness of material. Similar relationships were observed for second-order distortions. The relationship between line widening and impact toughness is found to be the same both for smooth samples, failing in the range from −190 – −120°, and for notched samples, failing between −80 and +20°. On the condition that in both cases the development of the failure is macroscopically identical (equal value of the impact toughness, degree of residual plastic deformation, etc.), the second-order (microscopic) distortions also prove to be identical, so that in regard to the development of second-order distortions the influence of low temperatures is found to be equivalent to the influence of sharp notches, or, high rates of loading. Extrapolation of the line widening in relation to the impact toughness to zero impact toughness (ideally-brittle failure) indicates that in this case also, there is perceptible plastic deformation.

From authors' summary

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**Book—206. Cazaud, R., Fatigue of metals [La Fatigue des metaux]**, 4th ed., Paris, Dunod, 1959, xvii + 574 pp. 6900 F.

This book became a classic in the field of the fatigue of metals when the first edition was published in 1937. It still is and it is hard to think of a researcher in the field who does not consult it regularly. The book is very comprehensive and well organized. The fourth edition just published has almost doubled the amount of material included in the third edition of 1948. A much larger number of examples than in the previous edition are given dealing with the physical appearance of fatigue fractures, and excellent photographs illustrate the examples. Considerations of the statistical evaluation of fatigue tests and on the determination of endurance limit by fast methods have also been added to the previous editions. That is also the case with the study of the influence of size.

The chapter dealing with the experimental means of determining strains is very short and rather incomplete. It gives some idea of how strains are measured experimentally, which may be useful to people in the fatigue of metals field but obviously is not appropriate for people more familiar with stress analysis methods.

An alphabetical index which was not included in previous editions has been added at the end of the book. This index will make the use of the book much easier. It may be advisable that the author also includes in the next edition a list of all the symbols used. The bibliography at the end of each chapter is remarkably complete and extremely well correlated with the text.

A. J. Durelli, USA

**207. Akaoka, J., and Hirasawa, K., Fatigue phenomena under rolling contact accompanied with sliding,** *Bull. JSME* **2,** 5, 43–50, Feb. 1959.

Rail steels and a locomotive tire steel were tested for fatigue in rolling, either without sliding or with a sliding velocity of ±10–14% of the rolling speed. When the direction of the tangential forces caused by the sliding friction is the same as the rolling direction, the life is longer than when these directions are opposed. Cracks always originate at the surface and propagate inward at an angle of about 40° to the rolling direction. In the absence of sliding, the cracks turn parallel to the rolling direction on reaching the position of maximum shear stress. If sliding is occurring in either direction, the cracks continue to propagate inward after reaching the depth at which the shear stress is a maximum.

F. R. N. Nabarro, So. Africa

**208. Smith, C. R., Fatigue—service life prediction based on tests at constant stress levels,** *Proc. Soc. Exp. Stress Anal.* **16,** 1, 9–16, 1958.

Notched specimens ($K_t$ = 2.4) of 7075-T6 aluminum alloy were tested in fluctuating tension. The cumulative life for a spectrum of 5 stress levels was approximately five times that calculated on the basis of conventional fatigue tests. When the comparison was based on specimens that had been loaded once to the highest stress in the spectrum prior to testing, the calculated cumulated life agreed fairly well with experiment.

Tests of riveted joints showed a complicated effect due to static preload.

J. A. Bennett, USA

**209. Eiro, O., Fatigue of welding materials** (in German), *Acta Polytech. Scandinavica* no. 250 (Mech. Engng. Ser. no. 3) 26 pp., 1958.

**210. Hult, J., Experimental studies on fatigue crack propagation in torsion** (in English), *Kungl. Tekn. Högskol. Handl.* no. 119, 46 pp., 1958.

A previous theory for the initiation and growth of fatigue cracks in torsion is reviewed. It is extended to the case of crack growth from a rounded vee-shaped notch.

Experiments have been made to study crack propagation in reversedly twisted aluminum bars. The crack lengths have been measured during the tests with a special ultrasonic method. In different test series the applied load as well as the notch configuration has been varied. The results are in general agreement with the theoretical predictions as regards the initiation of and incipient crack growth.

A deceleration of the crack growth that is not predicted by the theory is found to follow the initial state. Possible reasons for this deceleration are discussed. Size effect and cumulative damage in fatigue are discussed in relation to the presented theory.

From author's summary by E. E. Sechler, USA

**211. Lebedev, T. A., The causes of fatigue and creep in metals** (in Russian), *Trudi Leningr. Politekhn. In-ta* no. 4, 138–153, 1953; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2408.

The failure of a polycrystalline material is considered as a process of rupture of interatomic bonds under the action of stresses generated by external forces as well as by temperature fluctuations in the atoms and mechanical vibration of the microscopic volumes in the material. The specific nature of fatigue failure is explained by the interference of local vibrations (the peaks of the vibrational stresses are summated to the fundamental stresses). Failure in creep is associated with local temperature fluctuations. Author attempts to establish a qualitative connection between the phenomena of creep and fatigue, based on the influence of atomic temperature fluctuations on mechanical strength. The suggested theory of fatigue failure is not well-founded. The dynamic relationships between the imaginary elementary volumes forming the body (sample or machinery part) are not followed up, and consequently the conception of a vibrational stress condition is indefinite.

R. D. Vagapov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**212. Goltsev, D. I., The fatigue strength of steel under asymmetrical bending or torsion** (in Russian), Problems of dynamics and dynamic strength no. 3, Riga, Akad. Nauk LatvSSR, 1955, 53–64; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2410.

Analytical expressions are presented for determining the limiting values of asymmetrical loading cycles in the bending or torsion of smooth samples. Author assumes a linear relationship between the amplitudes of the tangent and the octahedral stresses of the equivalent cycle due to the variable and the static components of the normal and tangential, octahedral stresses in an asymmetrical loading cycle. The calculation of the area of the octahedral hysteresis loop of an asymmetrical cycle is performed by means of formulas in which the amplitude values are replaced by the peak stresses of the cycle. The comparison made between the analytical and the experimental results shows good agreement.

V. F. Balashov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**213. Kashkarov, K. P., The fatigue endurance of timber** (in Russian), Issledovaniya prochnosti i deformativnosti drevesiny, Moscow Gos. Izd-vo Lit. po Str-vu i Arkhitekt., 1956, 68–92; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2492.

The decrease in mechanical strength under a continuing load has (hitherto) been assessed by introducing a "coefficient of endurance"—the ratio of the long-term (fatigue) strength of the original sample to the short-term ultimate strength of an identical, "twin" reference sample. The influence of the loading rate in tests, within the limits of 0.0035 to 5020 kg/min, has been investigated. The essential conclusions arrived at are: the fatigue strength of pine timber (sapwood) in bending, compression, tension, and splitting along the grain is less than half the short-term ultimate strength; the total deformation in transverse bending has two com-

ponents of different nature: conditionally-instantaneous deformations remaining proportional to the load up to failure, and hysteresis deformations following a curvilinear law independent of the duration of loading; hysteresis deformations under loads not exceeding 90% of the breakdown load are reversible; during deformation under a load increasing at a constant rate the two mechanical conditions of wood according to Yu. M. Ivanov ["The limits of plastic flow," Stroyizdat, 1948], the boundary between which is the stress corresponding to the limit of plastic flow, are not observed. A. N. Mitinskii

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**214. Garf, M. E., Determination of dynamical errors in fatigue tests** (in Ruggian), Izmerenie Napryazhenii i Usilii v Detalyakh Mashin, Moscow, Mashgiz, 1955, 214–223; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 1373.

Errors due to wobbling of samples are examined. It is shown that the stress determined from a deviation of spring and the stress bending the sample are different. Such a scheme of loading evokes additional dynamic stress which makes the cycle asymmetric but does not change the value of amplitude of the stress. Relationships are given between stresses and the coefficient of asymmetry of the cycle. Schemes are presented of apparatus for remote measurements and test data are compared with calculation results. L. M. Rubinshtein

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

## Experimental Stress Analysis

(See Revs. 77, 123, 177)

## Material Test Techniques

(See also Rev. 224)

**215. Baes, L., and Verwilst, Y., A large mechanical installation for duration tests,** *Proc. Soc. Exp. Stress Anal.* **16,** 1, 39–56, 1958.

An installation for testing large structures or subassemblies for endurance under either static or dynamic loading has been developed and put into operation at the premises of the Association des Industriels de Belgique (A.I.B.), Auderghem, near Brussels.

The installation represents a complete generalization of the principle of the conventional testing machine, which consists of a frame taking up the reactions to the test loads, a loading unit, and a weighing unit. To overcome the limitations imposed by the size of the conventional testing machine frame, the loading unit of the new equipment has been separated from its frame, and is used with a suitable test rig so that, instead of introducing the specimen into the machine, the machine is built around the specimen. This was achieved by the construction of a heavily reinforced concrete floor having a system of built-in anchor points to which the members of testing frames, loading mechanisms, scaffolding and other equipment may be affixed. Auxiliary equipment enables the application of forces at a plurality of points on the specimen and in practically all directions, so that the effects of simultaneous service loadings may be accurately duplicated in a test specimen. Loads are applied with hydraulic jacks, and when they are static they are measured with pendulum dynamometers. For dynamic tests, hydraulic pulsators are used, the loads being measured with manometers.

The installation, generally referred to as G.I.M.E.D., is described in detail. Several examples are given of the application of the equipment. From authors' summary

**216. Volterra, E., and Barton, C. S., An impact testing machine for plastics and rubber-like materials,** *Proc. Soc. Exp. Stress Anal.* **16,** 1, 157–166, 1958.

A testing machine for studying dynamic properties of plastics and rubber-like materials under impact loading is described. The cylindrical specimens to be tested are placed on the plane end of a short steel bar hung as a ballistic pendulum. Another bar, also hung as a ballistic pendulum, is made to impinge upon the specimen. The force acting on the specimen during the time of impact is measured by an accelerometer fixed to the impacted bar. From the acceleration-time diagram, which is recorded on an oscilloscope, the force acting on the specimen during impact is measured. The length of the specimen during impact is determined by integrating twice the acceleration-time diagram. This accelerometer method represents a considerable improvement in experimental accuracy as compared with the optical method (drum-camera method), which has been described in a previous paper, and in which method the dynamic parameters of the specimen were obtained by photographing the distance between the two bars during impact.

Experiments conducted using this accelerometer method under different conditions of temperature and impact loadings are described and the results compared with those obtained by the drum-camera method. From authors' summary

**217. Volkova, T. I., Prolonged testing for relaxation of spring steels** (in Russian), Tests for and properties of heat-resistant materials, Moscow, Mashgiz, 1957, 149–158; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6172.

Results are given for prolonged (up to 10,000 hours) tests for relaxation of steels marks 4 Kh13, R 18, EI 290 and TsZh-4 (EI 723) at temperatures of 410 and 470° with different initial stresses. At 470°, steel TsZh showed the highest relaxation stability. At the value $\sigma_{10,000}$ it exceeded that of steel R 18 by 35–45%. At 410° the maximum relaxation stability was exhibited by steel R 18. Extrapolations, carried out on the strengths of tests over less than 2500-hours duration, did not quite establish themselves. G. A. Tulyakov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**218. Oppel, G. U., A new rough surface hardness test for metals based upon full indentation of a ball** (in English), *Forsch. Geb. Ing.-Wes.* **24,** 5, 149–153, 1958.

Usual hardness tests fail for rough surfaces caused, for example, by casting and hot working or by surface coatings. Author proposes a testing method with full indentation of ball. Mathematical analysis delivers that load remains constant for a penetration of ball more than about 2/3 of its diameter $d$, and that hardness $H_p$ determined by this load is related to Brinell hardness $H_B$ and to ultimate tensile strength $\sigma_u$ by linear relations. These results are confirmed by experiments. A penetration hardness tester with additional scales for $H_B$ and $\sigma_u$ is described. Test piece thickness $b$ must be larger than twice $d$ in order that $H_p$ is independent of $b$. Author assumes that by measuring the properties of material below surface a more correct value of hardness results. A. Kochendorfer, Germany

**219. Mirkin, I. L., and Trumin, I. I., A statistical method of investigating the zone of disruption of metals by measuring the microhardness** (in Russian), *Zavod. Lab.* **23,** 2, 229–235, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6116.

The degree of break-up of the metal was evaluated by the change in dimensions of the impression due to pressure. The condition of the metal in the region adjacent to the crack was followed by the statistical method with the determination of the probable "Modal'nykh" values for the microhardness on the frequency curves. Measurements on three microslides of a steel type EI-10 showed that the processes preceding the emergence of visible seats of disruption lead to the break-up of the metal in a zone ~ 100$\mu$ from the crack. G. A. Tulyakov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**220. Mikhailichenko, N. G., A method of determination of mechanical characteristics of a metal from a torsion test of samples** (in Russian), *Zavod. Lab.* **23**, 1, 83–87, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 1287.

In comparing some advantages of investigation of a meterial in torsion with the conventional test on tension, a method is proposed to work out results of investigation of torsion which allows the determination of all fundamental mechanical characteristics of a metal. Some theses and recommendations of the author, however, appear controversial (for example about "a supporting influence" of the elastic core of the sample" on the proportionality zone as well as a method of determination of this zone).

S. V. Boyarshinov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**221. Pavlik, A., Some remarks about the measuring of physical and mechanical properties of concrete mixtures** (in Czechoslovakian), *Stavenbnicky Casopis* **5**, 2, 94–102, 1957.

## Properties of Engineering Materials

(See also Revs. 89, 92, 93, 94, 195, 200, 204, 207, 208, 217, 221, 279, 388, 453)

**222. Shirakawa, Y., and Miyazaki, T., Magnetic properties of spheroidal graphite cast iron,** *Sci. Rep. Res. Inst. Tohoku Univ., Japan (A)* **10**, 6, 399–404, Dec. 1958.

Experiments by authors show that under same degree of graphitization, maximum induction, coercive force and hysteresis loss of spheroidal graphite cast iron were lower than those of flake graphite cast iron, and maximum permeability and residual induction were higher. G. G. Meyerhof, Canada

**223. Schmatz, D. J., and Zackay, V. F., Mechanical properties of deformed metastable austenitic ultra high strength steel,** *Trans. Amer. Soc. Metals* **51**, 476–494, 1959.

A new hardening technique applicable to most steels of high hardenability has been investigated. The process consists of plastically deforming metastable austenite in alloy steels at a subcirtical temperature, where the austenite is relatively sluggish, and subsequently transforming the deformed austenite to a martensitic product. The effect of deformation on hardness, tensile properties, and microstructure was determined for steels containing 0.28 to 0.57% carbon. A hardness increase of from 2 to 4 points Rockwell "C" was obtained with deformations ranging from 25 to 75% with attendant increases in tensile strength and yield strength. Yield strengths in excess of 300,000 psi were obtained by tempering the deformed steels. At this strength level, ductilities of from 6 to 8% were consistently reproduced. Electron micro graphs of the deformed steels indicated a refinement of the martensite. Several suggestions were advanced for the mechanisms responsible for the striking improvements of the tensile properties of these steels. From authors' summary

**224. Hendrickson, J. A., and Wood, D. S., The effect of rate of stress application and temperature on the upper yield stress of annealed mild steel,** *Trans. Amer. Soc. Metals* **50**, 498–508, 1958.

Authors review two theoretical treatments of the upper yield stress phenomenom in terms of dislocation theory and present experimental data to test validity of theories. Upper yield stress data for annealed low-carbon steel are presented for various constant stress rates ranging from $10^2$ to $10^7$ psi per second at −110 and −200 F. These yield stress data are compared to theoretical predictions based on prior measurements of delay time under constant stress. Authors conclude that the general aspects of dislocation theory of yielding are correct, and that accurate predictions may be made of the upper yield stress under more complex stress-versus-time conditions than those employed in this investigation.

D. E. Martin, USA

**225. Owen, W. S., Cohen, M., and Averbach, B. L., Some aspects of preyield phenomena in mild steel at low temperatures,** *Trans. Amer. Soc. Metals* **50**, 517–535, 1958.

In annealed mild steel tested at room temperature, discontinuous gross yielding occurs at, or above, the static upper yield stress only after a time delay during which the specimen undergoes a small nonelastic strain. A permanent microstrain also occurs at lower stresses, the elastic limit being defined as the lowest stress at which nonelastic strain can be detected. At subzero temperatures, the yield point is less well defined, and at −196 C (−320 F) the static yield stress has proved difficult to determine from the usual load-extension data because of the large nonelastic preyield strain and the long delay times. In this investigation the sequence of events leading to gross yielding at −196 C (−320 F) has been explored by metallographic techniques, by the observation of strain patterns on long thin prepolished specimens, and by precise strain measurements as a function of stress and time. It is found that the transition from the microstrain to Lüders' strain is not abrupt, as it is at room temperature, but occurs by a slowly accelerating creep process which, at certain stress levels, can occupy an appreciable time interval.

The influence of ferrite grain size, austenitizing temperature and cooling rate on the elastic limit and preyield phenomena has been surveyed. The total nonelastic strain at the static yield stress, unlike the yield stress itself, is dependent upon the austenitizing temperature and cooling rate rather than the grain size. The elastic limit at −196 C (−320 F) varies relatively little with grain size, but the elastic limit at room temperature shows a pronounced grainsize dependence. The implications of these data are briefly discussed in qualitative terms by reference to the Clark-Wood dislocation model. From authors' summary

**226. Shurakov, S. S., Dependence of the toughness of a hardened steel on the period of its being under load** (in Russian), Metal working, Leningrad, Sudpromgiz, 1957, 100–126; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6126.

Results are given of experiments on the investigation of the so-called delayed disruption, when, during stresses lower than the customary (momentary) limit of toughness (yield strength), a fracture occurs of the test sample in tension, some time after the loading had started. The effect is described of the sharp lowering of the limit of yield strength (by several times) of the hardened steel at low tempering; the effect lessened with a period of rest after hardening and with increase in the temperature of the tempering. A hypothesis is adduced on the physical nature of the phenomenon. Some data are furnished regarding the influence of the rate of loading on the magnitude of the residual stresses during deflection and torsion. I. K. Snitko

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**227. Borisov, V. S., and Naumov, F. N., Influence of tempering on the mechanical properties of chrome-plated components** (in Russian), *Metallovedenie i Obrabotka Metallov* no. 12, 50–56, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6127.

Electrically chrome-plated samples were subjected to tests for tension, impact deflection and fatigue during bending. Tempering the samples at 100–300° did not increase the yield strength and the relative elongation of the steels being investigated, did not lead to improvement of their resistance to impact deflection, but worsened their resistance to the action of cyclic loading.

G. A. Tulyakov

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**228. Drits, M. E., and Moguchii, L. N., Mechanical properties of a deformed alloy MA 9 at high temperatures** (in Russian), Strength of metals, Moscow, Akad. Nauk SSSR, 1956, 190–198; *Ref. Zh. Mech.* no. 5, 1958, Rev. 6166.

Investigational tests were carried out of the plastic and strength properties of an alloy MA 9 at room and higher temperatures and at different speeds for the tests, which were carried out by the methods of static and dynamic reaction of forces.

From authors' summary

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**229. Sivic, C., Use of aluminum alloys as structural materials** (in Croation-Serbian), Naše Gradevinarstvo **13**, 3, 49–60, Mar. 1959.

Paper is an historical review of structural applications of pure aluminum (roofing of San Gioacchimo Church in Rome, 1900), discovery of first alloys (by Wilm, 1905), their further use (by Dornier, Zeppelin), first bridge (Smithfield near Pittsburgh, Pa., 1933), etc. Thorough description covers properties, composition, compounds, physical and chemical properties such as strength, corrosion, typical shapes of structural elements, extruded, riveted and welded, preferable structural types of walls, floors, roofs, bridges, etc.

J. J. Polivka, USA

**230. Schmatz, D. J., and Zackay, V. F., Mechanical properties of Fe-Al-Si alloys at room and elevated temperatures,** *Trans. Amer. Soc. Metals* **51**, 299–309, 1959.

An investigation of the mechanical properties of iron-rich, iron-aluminum-silicon alloys was conducted. Silicon was used as the independent variable at three aluminum levels; 5, 7, and 9 weight %. Silicon increased the strength at both room and elevated temperatures. Ductility was markedly decreased by silicon and interstial elements, such as carbon. Silicon appeared to be more than additive to aluminum in improving the oxidation resistance. Room temperature electrical resistivity measurements on quenched and slow-cooled alloys indicated silicon was additive to aluminum in initiating order. Silicon also raised the ordering temperature rapidly. A correlation between ordering temperature, as determined by electrical resistivity, and creep rate was noted.

From authors' summary

**231. Harwood, J. J., New developments in metals and ceramics for high-temperature service (above 1000 F),** ASME Design Engng. Conf., Philadelphia, Pa., May 1959. Pap. 59-MD-2, 12 pp.

Changing requirements for materials for high-temperature operation have brought about different approaches and emphasis in the development of new types of high-temperature materials. Thermal properties of materials, refractory metals, thermal-protection systems and composite materials have assumed significant roles in the current materials-development picture. This paper discusses briefly the current approaches to the problems of high temperature and attempts a comparative evaluation of materials with respect to their high-temperature capabilities, potentialities, and limitations. Future trends in materials research and development are forecast. One of the important features of the current picture is the growing recognition of the necessity of considering materials, environment, and design as an integrated system.

From author's summary

**232. Calinescu, F., and Stanescu, N., Foam concrete in construction** (in Roumanian), *Rev. Construct. Mat. Construct.* **10**, 12, 607–613, Dec. 1958.

Authors thoroughly review studies, experiments and applications of precast structural elements of foam concrete, especially with "spumogone," hardened by steam or treated in autoclaves at 8 atm pressure. Also structures cast on the site and hardened in usual way are described.

J. J. Polivka, USA

**233. Tatur, G. K., Approximate calculation for the deformation capacity of a ring-shaped pliable timber support** (in Russian), *Sb. Tr. Krivorozhsk. Gornorudn. In-ta* no. 5, 79–89, 1956; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4743.

A ring-shaped pliable prop is examined, consisting of four round segments, joined together by four friction scarf-joints. An evenly distributed radial pressure acts on the prop; this results in deflection of the segments and their displacement relative to the scarf-joints, which causes a reduction in the prop's radius. The relation is established between the segments' displacement relative to the scarf joints and the magnitude of the external pressure, both for elastic as well as elastic-plastic deformations of the segments. The calculation of the solution for the elastic-plastic zone leads to the calculation of a rod under the joint action of deflection and compression; the material of which the rod is made is assumed to be ideally plastic. Formulas are proposed for the determination of the deflection moment $M_{y,n}$ and the longitudinal force $N_{y,n}$, by whose action the elastic zone in the rod's section has a given height

$$M_{y,n} = M_n - \Delta M, \quad N_{y,n} = N_n + \Delta N \qquad [*]$$

where $M_n$, $N_n$ are the values of the deflection moment and the longitudinal force, under whose action all the sections are found in the plastic zone; $\Delta N$, $\Delta M$ are the equally-acting and the deflection moments, respectively, relative to the axis, passing through the center of gravity, of stress $\sigma = \sigma_T - \sigma_y$ ($\sigma_y$ is the magnitude of the stress in the elastic zone).

The presentation of the formulas at [*] is incorrect, because when deducing them no account was taken of the fact that the position of the neutral axis depends on the degree of plastic deformation (the height of the elastic zone) and that for the elastic-plastic and pure plastic conditions it does not coincide. In addition, when making the deduction it was assumed that the height of the elastic zone is divided in half by the neutral line. This is only true for sections with two axes of symmetry and when the section contains two plastic zones.

Yu. A. Rakovshkhik

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**234. Svatov, M. S., Changes in the physico-mechanical properties of pine wood due to the combined influence of negative temperatures and humidity** (in Russian), *Trudi Akad. Neft. Prom-sti* no. 3, 260–273, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6203.

The dry wood cooled to a low negative temperature had higher limits of strength in all the forms of tests carried out than the wood at room temperature. The increase in strength is explained as due to the hardening of the pectin constituents of the wood and the general contraction of the wood fibers (compacting) under the action of negative temperatures.

From author's summary

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**235. Kornilovich, Yu. E., Strength of light concretes** (in Russian), *Novoe v. Stroit. Tekhn.* no. 11, 112–141, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6183.

In order to derive general formulas for the strength of light concretes an attempt is made to formulate a general theory of strength. The experiments carried out by the author show that the strength of the concrete continues to increase even when the mixture attains the strength of the filler. Resulting from these experiments and with the addition of a few theoretical concepts formulas are proposed for the calculations of the strength of clay-filled concrete (and for slag-filled concrete) mixed with quartz sand. One of these formulas makes it possible to find the water/cement relation in cases where it is essential to select a concrete brand with a strength greater than that of the fillers; the second formula serves the purpose of selection of a concrete brand with a strength less than that of the filler. K. S. Zavriev

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**236. Titkov, N. I., and Don, N. S., The dynamics of the mechanical strength of cement test samples after long storage in various media** (in Russian), Neftyanik no. 8, 29–30, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6194.

The samples were tested over a period of three years. An intensive increase in deflection stability took place up to a period of ninety (24-hr) days and in compression 180 days.

From authors' summary

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**237. Perekhvatov, V. K., The influence of the time factor on some characteristics of high-grade concretes** (in Russian), *Trudi Gorkovsk. Inzh.-Stroit. In-ta* no. 25, 16–27, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2463.

Author concludes that allowing for the actual intensity of growth of the strength and deformation capacity of concrete made with quick-setting cement and with a low water-cement ratio, it should be possible to reduce curing time and hasten the instant of load-application. From author's summary

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**238. Volkov, S. D., The theory of mechanical strength** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **112,** 4, 632–635, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2342.

The statistical condition of the strength of gypsum is examined [*Zh. Tekh. Fiz.* **23,** 11, 2025–2044, 1953] as a generalization of the hypothesis which, in the author's opinion, gives under comparable conditions better agreement with experimental results than the classical theory of mechanical strength.

From author's summary

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**239. Gruntfest, I., Developments in plastics for high-temperature service (above 1000 F),** ASME Design Engng. Conf., Philadelphia, Pa., May 1959. Pap. 59-MD-1, 6 pp.

Most plastics soften and decompose at temperature below 1000 F, hence for continuous service above 1000 F their use is out of the question. But for short-time exposures, such as are met in rocket motors or in the skin of high-speed aircraft and missiles, the possibility of using plastics must be reexamined. This paper analyzes the thermal conditions met in high-speed applications and describes in detail the four stages that the material being heated may go through. These are: (1) No temperature gradient at the surface, the heat input being exactly balanced by the radiation from the surface; (2) equilibrium temperature above the melting temperature of the material, at which melting begins and there is a slow recession of the surface; (3) heating is sufficiently severe to cause vaporization of the plastic material of a part; and (4) chemical reactions occur. The paper covers the phenolics, graphite, Teflon, glass-reinforced phenolics, and other plastic materials of the thermosetting type. Tables and graphs are included.

From author's summary

**240. Maksimovic, M., Materials and structures in housing construction** (in Serbian), Naše Gradevinarstvo **13,** 1, 3–5, Jan. 1959.

Digest of a report of Yugoslav Union of Laboratories for Testing Materials issued in June 1958. Author is the head of the department for research work in buildings at the Institute for Testing Materials, Beograd. Symposium emphasizes needs for further research work to modernize the building industry and the production of adequate building materials, especially of lightweight concrete.

J. J. Polivka, USA

## Structures: Simple

(See also Revs. 107, 109, 117, 120, 126, 174, 182, 187, 201, 229, 235, 237, 506)

**241. Camiz, V., Introduction to a general method for the solution of plane frames** (in Italian), *G. Gen. Civ.* **96,** 9, 570–575, Sept. 1958.

Paper presents a general method for computation of two-dimensional framed structures composed of beams with variable sections and curved or polygonally shaped axis under an arbitrary load. Considering first the single, unloaded beam with bending moments and forces on the ends, author develops the equations which connect the four unknown characteristic deflections (joint-rotations, rotation of the chord and axial deflection) with the three main forces acting on the joints (bending moments and axial forces). The determination of the deflections may be realized by one of the well-known methods (e.g., Unold, Cross, etc.). The two particular cases of articulated and rigid fixed ends of the beam are derived from the general case. It is underlined that the equations include each particular type of joint between the different beams. No mention is given to the determination of the unknown deflections. H. Beer, Austria

**242. Fuxa, U., Further considerations on the drawing of the influence lines of the bending moments and shearing stresses and detailed consideration on the drawing of the characteristic influence line of the deflection of the continuous beams with fixed supports and single-storey, multibay frames** (in Italian), *G. Gen. Civ.* **96,** 9, 576–586, Sept. 1958.

In continuation of some former papers author gives the equation of the "characteristic influence line" of the beam with elastically fixed ends. Using this "characteristic" he derives the influence lines of bending moments and shearing stresses for the continuous beam in an analytic way, presenting the corresponding equation by means of some parameters. Influence lines of deflection in an arbitrary section of the beam can be found in a similar manner. This method can be applied to the single-storey, multibay frame taking into account the elastic rotation of the joints. Reviewer believes that other well-known methods for drawing influence lines are less complicated, but sometimes it may be useful to have an analytic representation of these lines. H. Beer, Austria

**243. Sen Gupta, S. R., Some modern trends in the design of frame structures: Theory of design based on plastic failure** (Presidential address), Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India, Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 1–18.

Brief exposition of known principles and methods.

A. J. Bignoli, Argentina

**244. Tokarski, E. W., Application of the plastic-hinge method to a multiple-story frame,** *Concrete Constr. Engng.* **54,** 2, 85–95, Feb. 1959.

Plastic theory is used as tool to analyze redundant concrete (i.e. nonplastic) frames. Method is essentially an extension of work of A. L. L. Baker [e.g. AMR **9** (1956), Rev. 2922], in which hinge rotations have to be calculated to check that these are within safe limits. J. Heyman, England

**245. Rayevskaya, E. A., The theoretical evaluation of the load-bearing capacity of double-tee joists in simultaneous bending and torsion** (in Russian), Researches on the theory of structures, no. 7, Gosstroiizdat, 1957, 269–298; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2142.

An investigation of the case of a steel cantilever beam of double-tee cross section under the action of combined bending and torsion, seeking the loading value which will create the limiting state. The problem is solved by the method of limiting equilibrium. Examining the static aspect of the problem and applying the equilibrium equations for the undistorted case, author arrives at an equation expressing the load-carrying capacity of the joist, above and below. In the first case, "alleviated" conditions are applied:

$$|\sigma| \leqslant \sigma_T, \qquad |\tau| \leqslant \tau_T = \frac{\sigma_T}{\sqrt{3}}$$

for the plasticity; while in the second case, the plasticity condition is applied in the form:

$$\sigma^2 + 3\tau^2 = \sigma_T^2$$

Different cases are examined of the action on the beam: stepwise torsion, free torsion, and pure bending, constrained torsion with pure bending; transverse bending and stepwise torsion.

From author's summary

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**246. Borges, J. F., Rectangular staircases without beams,** Minis. Obras Publicas, Lab. Engen. Civ., Lisboa, Publ., Tech. Pap. 121, 13 pp., 1958.

The results of model and prototype tests on rectangular staircases composed of slabs without beams are presented.

Design methods of this type of stairs are discussed. Such discussion is based on the interpretation of the experimental results. It is shown that to solve the problem it is especially important to determine the vertical deformability of the intersection line of the flight and landing slabs. From author's summary

**247. Krishnan, S., and Shetty, K. V., Limit design formulas for thin-walled columns and application to redundant structures,** *J. Aero. Soc. India* **10,** 4, 57–62, Nov. 1958.

**248. Bechert, H., Remarks about the calculation of sidewise movable frames using the momentum-equalization procedure** (in German), *Bautechnik* **35,** 10, p. 401, Dec. 1958.

**249. Roussopoulos, A., Theory of elastic complexes and elastic connections** (in Greek), reprinted from *Technika Chronika* nos. 403–408, Jan./June 1958, 85 pp.

A detailed exposition of a method developed by the author for the analysis of elastic structures by the use of matrices. The method can be used for the analysis of any structures, plane or three-dimensional, which may be constructed by the interconnection of a finite number of rigid disks or bodies by means of elastic beams of any arbitrary shape. In a given elastic structure these rigid disks are either actual parts of the structure or fictitious weightless rigid disks of arbitrary dimensions which are assumed as attached to a material point of the structure. This point may be either a joint or a point along one of the connecting beams. In the latter case the beam in question is broken into two separate connecting beams.

The formulation of the method consists of the study of the structural behavior of a system of four rigid disks of the structure, $\alpha$, $\beta$, $\gamma$, and $\delta$, which constitute an "interdependent unit" of the structure, denoted by $\alpha\beta\gamma\delta$. The following fundamental problem is considered: For a given system of equal and opposite forces and moments acting on $\alpha$ and $\delta$ find the relative displacement of the disk $\gamma$ with respect to the disk $\beta$. The solution of this fundamental problem is formulated using matrices of stiffness and compliance of the interdependent unit. The meaning of interdependent units with one or two repeated indices (i.e., disks) is explained in accordance with the general definition. Subsequently, all interdependent units are expressed in terms of "fundamental interdependent units," which are obtained by reference of the position and loading of each disk with respect to a "ground" disk. Formulas are given for the computation of the elastic matrices of interdependent units and the transformation of these matrices under a transformation of the coordinate system. The basic elastic properties of deformation and resistance which are implied by these elastic matrices are thoroughly discussed. The problem of static analysis of any structure is thus systematically reduced to algebraic operations on matrices. An especially simple case is that of plane structures, and the topologically equivalent case of multistory structures, with floors rigid against deformation in their plane. Reduced formulas are given for this case, an application of which is the design of multistory buildings under the action of horizontal loads such as wind or seismic loads.

D. C. Gazis, USA

**250. Sattler, K., Contribution to the calculation of prestressed concrete constructions** (in German), *Bauingenieur* **31,** 12, 444–457, Dec. 1956.

**251. Salter, C., Wind loadings on flat-roofed buildings,** *Engineering* **186,** 4832, 508–510, Oct. 1958.

**252. Howells, D. A., Structures to withstand earthquakes,** *Engineering* **187,** 4853, 346–348, Mar. 1959.

The drafting of building regulations in earthquake areas for the structural designer are discussed. From a study of the response of simple single mass oscillators to the accelerographs recorded in recent strong earthquakes in the western United States an idealization of earthquake motion as a random series of impulses is developed. Theoretical consideration of the response which may be expected to random impulses gives a principle of value in designing against future earthquakes. The use of computers to enable the response of more complex idealized structures is also examined. From author's summary

## Structures: Composite

(See also Revs. 72, 90, 159, 204, 233, 240, 406, 506, 536)

**253. Granholm, M. H., Laminated and nailed wood structures: theory and applications—attempted explanations of failure of the centering of the bridge at Sandö** (in French), *Ann. Inst. Tech. Bat. Trav. Publics* **12,** 133, 25–38, Jan. 1959.

Author derives theory which allows for flexibility of the connecting means. Introducing modulus of displacement of connections as a fraction of the unit load taken by a nail and corresponding displacement and some necessary simplification, a partial differential equation is obtained as a relation between shear stress and deflection of considered beam. Solution, obtained using double series, gives distribution of shear and bending stresses as well as expression in closed form for flexural beam rigidity. For practical pur-

poses author gives simplified procedure using simple series. Obtained results are checked for agreement with the homogenous cross sections and performed tests.

Using developed theory an attempt is made to give new explanation for the failure of the centering of the bridge at Sando, giving relation between actual and [the previously calculated] critical stress.

Reviewer believes that the established theory represents a great improvement of the known methods used to date for laminated structures, the only limitation introduced being in the elimination of bending stress by assuming validity of Hooke's law, thus putting the problem in the elastic range only.

B. O. Kuzmanovic, Sudan

**254. Barbre, R., and Ibing, R., Wind tunnel experiments on the safety against wind induced vibrations of the Koln-Rodenkirchen suspension bridge** (in German), *Stahlbau* **27**, 7, 169–176, July 1958.

**255. Berger, E. Ya., Calculations for the transverse rigidity of prefabricated ferroconcrete bridges** (in Russian), Trudi Kievsk. Avtomob. -dor. In-ta 3, 74–85, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4713.

**256. Herzog, M., Contribution to the successive approximation method of calculation of reverse bend dams** (in German), *Bautechnik* **34**, 8, 298–301, Aug. 1957.

**257. Tadova, O., Influence of buoyancy on the design of dams** (in Czechoslovakian), *Stavebnicky Casopis* **5**, 2, 77–93, 1957.

**258. Rocha, M., Serafim, J. L., and Da Silveira, A. F., A method of quantitative interpretation of the results obtained in the observation of dams,** Minis. Obras Publicas, Lab. Engen. Civ., Lisboa, Publ., Tech. Pap. 128, 26 pp., 1958.

This paper presents a method for the quantitative interpretation of the observation of the behavior of dams.

It is possible by means of its application to separate the various loadings which act on a dam. Among the most important are those resulting from hydrostatic pressure and temperature. The parameters that define these two loadings are discussed. The general expressions to be considered to represent the different magnitudes measured are also discussed.

Some examples are presented of practical application to the measurements of displacements, strains and stresses. For these magnitudes it was possible to separate the contributions due to the hydrostatic pressure and to the temperature.

A critical analysis of the method is presented at the end of the report. The direction to be followed in future researches to increase the efficiency and reliability of the method is also indicated. From authors' summary

**259. Talobre, J., Statics of anchor-bolts in rock workings** (in French), *Construction* **12**, 12, 439–445, Dec. 1957.

**260. Csecskedy, G., Girders on elastic foundation and hinged chains** (in Hungarian), *Viz. Kozl.* no. 3, 191–211, 1957.

## Machine Elements and Machine Design

(See also Revs. 31, 86, 112)

**Book—261. Serensen, S. V., Kogaev, V. P., Kozlov, L. A., and Shneiderovich, R. M., Carrying capacity and calculations for stability of machine parts** (in Russian), Moscow, Mashgiz, 208 pp. 1954, 10r 70k; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6112.

This text book is devoted to the basic calculations for machine components under nonstationary stressed states with conditions of plastic deformation, during brittle disruption and in the presence of variable stresses of different characters. In addition, investigations are carried out on the calculations for rollers and shafts, bolted joints, springs and other flexible parts, and rotating elements. Data for reference for calculations of machine components are given. S. Ya. Makarov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**262. Peres, N. J. C., On the difference between the normal plane helical gear profile and the virtual spur gear approximation,** *Austral. J. Appl. Sci.* **10**, 1, 17–24, Mar. 1959.

Author remarks that helical involute gears are sometimes milled with rotary cutters whose form corresponds to the tooth space profile of an imaginary "virtual" involute spur gear in the plane normal to the pitch cylinder helix and he gives equations for the difference between the profile so produced and the correct normal plane profile. Discussion shows that for small gears with large flank curvature the errors of the approximation are significant.

O. Bottema, Holland

**263. Peres, N. J. C., Involute gear geometry,** *Austral. J. Appl. Sci.* **10**, 1, 25–44, Mar. 1959.

Author has given [*Austral. J. Appl. Sci.* **5**, 309–329, 1954] considerations about the geometry of a single involute helicoidal surface making use of vectorial methods. The treatment is extended here to the general case including every tooth and space in any gear. Paper is of a highly mathematical character and deals with the base cylinder tangent plane and the general asymmetric chord. Application to sphere in tooth space is added.

O. Bottema, Holland

**264. Artobolevski, I. I., Dynamic criterion of gear mechanism running** (in German), *Maschinenbautechnik* **7**, 12, 663–667, Dec. 1958.

The kinetic parameter is introduced representing the state of moving mechanism. It is a ratio of angular acceleration to angular velocity of the mechanism at any moment of time or any angle of rotation. This ratio, which is a ratio of rate of increase of angular velocity to angular velocity at this particular moment, could be represented as the difference of two analogical ratios of total kinetic energy of mechanism and total reduced to the same center line of rotation moment of inertia of mechanism. The actual values for some machines are given and significance for calculation of moving parts is discussed. The way to reduce this parameter is presented and applied to a hypothetical example in detail. The application of dynamic compensators is mentioned in a general way.

W. de O'Byrn, England

**265. Lichtenheldt, W., Geometry of three-dimensional drives (link ways) for predetermined requirements** (in German), *Maschinenbautechnik* **7**, 12, 668–671, Dec. 1958.

The two systems of three-dimensional crank shaft are discussed in detail: (a) with spherical joint crank pin and (b) with standard crank pin.

Details are given for type (a) in graphic form for angles between plane of crank and plane of slide 10°, 20°, and 30°. The dimensions of drive could be selected for agreed minimum transfer angle and return stroke angle, and practical limits of them are also mentioned.

For type (b), which is more suitable for larger angle, graphs are given for 45° as the best value with angles of return 180°, 175°, 170°, of which only 180° is considered to be of practical value.

W. de O'Byrn, England

**266. Altmann, F. G., Determination of geometric dimensions of three-dimensional coupling gear mechanisms for prescribed conditions** (in German), *Maschinenbautechnik* **7,** 12, 672-679, Dec. 1958.

The ways of guiding a rigid body with one degree of freedom are presented. The most practical guiding surfaces and curves are pointed out and illustrated with models. The five-, four- and three-points guide of body in space are demonstrated in models and discussed. The models are given for guiding a body through three positions in space and mention is made regarding two-position guide. The symbolic representation of guiding systems is given and discussed on all models. W. de O'Bym, England

**267. Egawa, T., and Taneda, M., External pressure produced by multi-layers of rope wound about a hoisting drum,** *Bull. JSME* **1,** 2, 133-138, June 1958.

Relationship between the pressure of a wire rope wound on a hoisting drum and the number of layers wound on the drum is derived. Numerical results are plotted for typical combinations of parameters. Experimental results from resistance strain-gage readings on a model hoisting gear check well with authors' theory.
R. W. Gretter, USA

**268. Terplan, Z., Science and research in the field of mechanism engineering in Hungary** (in German), *Maschinenbautechnik* **8,** 2, 107-110, Feb. 1959.

**269. Artobolevskii, I. I., The theory of the mechanisms of cleavage formations and its applications to cyclic curves** (in Russian) *Akad. Nauk SSSR Trudi Sem. Teor. Mash. Mekh.* **17,** 65, 37-72, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6342.

A general method is described for the synthesis of mechanisms employed in building-on cleavage formations to given curves. Based on this method cleavage formations were obtained for building on to the following curves: (1) cycloid, (2) trachoid, (3) epicycloid, (4) shortened epicycloid, (5) elongated epicycloid, (6) hypocycloid, (7) shortened hypocycloid, (8) elongated hypocycloid, (9) circle evolvents. Special cases of these curves are examined separately. Mechanisms are also indicated for the formation of curves allied to cycloid curves. N. I. Lebitskii
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**270. Beletskii, V. Ya., The imparting of greater precision to the dimensions of plane mechanisms with the lowest pairs reproducing the given principle of motion** (in Russian), *Trudi Odessk. Tekhnol. In-ta* **8,** 37-47, 1957; *Ref. Zh. Mekh.* no. 6, Rev. 6343.

The solution is examined of the problem of synthesizing an articulated four-bar mechanism with an assigned relationship between the changes of position of the leading and working links. In order to calculate three or four parameters use is made of a multiple interpolation with one joint, the multiple effect of which is approximately equal to three or four. When making calculations for five parameters one parameter is found from the condition of the divergence from the given function $\Delta$ being equal to zero, the remaining four parameters from the condition of the minimum mean quadratic value of the second derivative of the function, approximately expressing the divergence $\Delta$. The method of calculation for five parameters appears to be faulty, as it does not guarantee, even at a single point, parity with zero of the first derivative from deviation $\Delta$, that is to say, the coincidence of direction of the tangential to the given function and to its approximate.
N. I. Lebitskii
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**271. Poplavskii, A. I., Grapho-analytical methods of statics in the kinematic analysis of plane mechanisms with the lowest pairs** (in Russian), *Naucbn. Trudi Mosk. Tekhnol. In-ta Legkoi Prom-sti* no. 9, 292-313, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6346.

In order to determine the angular speeds of the relative rotation of the links in a kinematic chain a recommendation is made to derive equations of "equilibrium" for the angular speeds, analogous to the static equations for the equilibrium of forces. Methods used in deriving and calculating the equations of "equilibrium" for the angular speeds are explained by examples. For the determination of the relative angular accelerations somewhat more complex equations are proposed. S. G. Kislitsyin
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**272. Prigorovskii, N. I., Bortkevich, V. I., and Grigor'ev, L. Ya., Procedure for investigating the stresses and forces in the parts of mechanisms of the impact type** (in Russian), Measurement of stresses and forces in the parts of machines, Moscow, Mashgiz, 1955, 188-213; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6248.

Descriptions are given of strain gages, of an amplifying and self-registering apparatus for the measurement of the parameters of impact, applicable to the investigation of an electrically operated pneumatic drill. The recording is done on an oscillograph with a mechanical (paper recording) unrolling device at a speed of 10 m/sec recording on a cinematic film. Results of tests on drill OMG are given. N. P. Raevskii
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**273. Goodman, T. P., An indirect method for determining accelerations in complex mechanisms,** ASME Ann. Meet., New York, N. Y., Dec. 1957, Pap. 57-A-108, 5 pp.

**274. Raven, F. H., Velocity and acceleration analysis of plane and space mechanisms by means of independent-position equations,** ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-2, 6pp.

**275. Hain, K., Diagonal angle arrangement in a linkage quadrangle,** *Ing.-Arch.* **25,** 3, 193-200, Apr. 1957.

## Fastening and Joining Methods

(See Revs. 209, 259)

## Rheology

(See also Revs. 65, 92, 93, 94, 470)

**276. Mirzadzhanzade, A. Kh., Determination of hydraulic resistances in a turbulent regime of motion of viscous-plastic liquids in pipes** (in Russian), *Doklади Akad. Nauk Azerb. SSSR* **13,** 7, 733-736, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6814.

The flow, as also is the case in the analogous theory for a viscous liquid, is divisible into two regions, the nucleus and the layer next to the wall. Utilizing dimensional analysis and by linearizing the relationships obtained from these concepts, author arrives at a two-term formula for the thickness of the layer next to the wall. By using this formula, and also the assumption on the linear distribution of velocity in the viscous layer next to the wall, author finds the constants in the logarithmic principle for the distribution of velocities in the nucleus of the flow and puts forward an expression for the coefficient of hydraulic resistance in relation to two Reynolds numbers—the one, of the same value as in the case of a viscous liquid; the other, equal to the relation of the product of density on the square of the characteristic velocity of

the flow to the boundary shear stress. The relationship obtained contains, in addition to the usual universal constants of the semi-empirical theory of turbulence in a viscous liquid, one universal constant which has to be determined experimentally. There are some misprints in the paper. G. I. Barenblatt

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**277. Solov'ev, E. M., Calculation of hydraulic losses in a ring-shaped space** (in Russian), no. 1, 40-44, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5333.

Results are given for the experimental determination of the loss of pressure when a clay suspension passes through a ring-shaped space between two concentric pipes (with diameters of 93.8 and 42.7 mm). Author describes the procedure, the experimental apparatus, the characteristics of the four clay suspensions used, and gives curves for loss of pressure using different quantities of clay suspensions and pure water. Formulas are given for the coefficient of loss by friction, in the ring-shaped space between the tubes, for the clay suspensions when in laminar and turbulent flow. Two numerical examples of the solution are given.

B. I. Yan'shin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**278. Berghaus, H. J., Flow of plastic bodies through tubes and orifices considering clay as an example** (in German), *Forsch. Geb. Ing.-Wes.* **23,** 4, 135-148, 1957.

**279. Babuska, I., About rheological properties of concrete** (in Czechoslovakian), *Stavebnicky Casopis* **6,** 1, 28-42, 1958.

## Hydraulics

(See also Revs. 294, 298, 324, 361, 471, 523, 526, 535)

**Book—280. Chow, V. T., Open-channel hydraulics,** New York, McGraw-Hill Book Co., Inc., 1959, 680 pp., $17.

Very important handbook for hydraulic engineers, unique in this form in the world literature of hydraulics. Book covers uniform flow, design of channels for uniform flow, theoretical concepts of mechanism of flow, gradually varied flow—backwater profiles, rapidly varied flow—spillways, hydraulic jump, bridge piers and culverts, unsteady flow—waves, surges, flood routing. Author deliberately avoids advanced mathematics and introduces many illustrative examples, in order to encourage users to solve intricate problems of this broad field. Author decided to cover many topics usually belonging to the hydraulics of structures, but eliminated silting processes (to be taught in another course of river hydraulics).

Carefully edited book shows great capacity and wide information of the author; comprehensive footnotes and over 800 correct references increase its value. New and enlarged tables of the varied-flow functions, published previously but not easily available, are of particular importance for users. Many good diagrams and tables, among them a large table of roughness coefficients, and series of pictures adorn the book. Author is to be congratulated with well-done important work, which will find a great acclaim in our schools and engineering offices. S. Kolupaila, USA

**Book—281. Khovanskii, G. S., Collection of nomograms for the hydraulic calculations of trapezoidal channels in conformity with the full formula of Academician N. N. Pavlovskii** (in Russian), Moscow, Izd-vo Akad. Nauk SSSR, 1954, 20r; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6675.

The volume consists of 24 nomograms with an oriented template (of large size), making it possible to solve with one application of the template-rule the system of equations

$$Q = \frac{(bh + mh^2)\sqrt{Ri}}{n} R^{\chi}, \quad \nu = \frac{\sqrt{Ri}}{n} R^{\chi}$$

$$\chi = 2.5\sqrt{n} - 0.13 - 0.75\sqrt{R}\,(\sqrt{n} - 0.10) \qquad [1]$$

$$R = \frac{bh + mh^2}{b + 2h\sqrt{1 + m^2}}$$

which come into use when carrying out calculations of the hydraulics of trapezoidal channels, using N. N. Pavlovskii's full formula. The nomograms have been drawn up for fixed values (0, 0.25, 0.5, 0.75, 1.0, 1.25, 1.5, 1.75, 2.0, 2.25, 2.50, 3.0). For each value of $m$, two nomograms are available. The template-rule with scales $Q$ and $\nu$ is of general application for all the nomograms. The limits of change of the variables are: $0.07\ m^3/sec \leqslant Q \leqslant 2000\ m^3/sec$, $0.07\ m/sec \leqslant \nu \leqslant 20\ m/sec$, $0.0001 \leqslant i \leqslant 0.1$, $0.011 \leqslant n \leqslant 0.030$, $0.15 \leqslant R \leqslant 3.3$ m, $0.3\ m \leqslant b \leqslant 4$ m, $0.7\ m \leqslant b \leqslant 30$ m, $b/h \leqslant \eta_{g.n.} = 0.5/(\sqrt{1 + m^2} - m)$. Examples are given of the solutions for the basic practical problems. Different cases are investigated of the transposition of the template over the immovable surface of the nomogram, which has to be done in some cases in order to preserve the constancy of one or other of the contacts, and an explanation in terms of hydraulics is given for such cases. By moving the template over the fixed surface it is possible to obtain a descriptive presentation of the mutual influence of values $Q$, $\nu$, $i$, $n$, $b$ and $h$ which have their places in Eqs. [1]. The application of the nomogram for the investigation of the properties of the hydraulically favorable sections of trapezoidal channels is demonstrated. Reference should also be made to G. S. Khovanskii, [*Gidrotekhn. i Melioratsiya*, 1953, (9), 33-35; Avtorefer. Diss. Kand. Tekhn. Nauk, In-ta Tochnoi Mekhaniki i Vychislit. Tekhniki AN SSSR, Moscow, 1955; Vychislit. Matem. i Vychislit. Tekhnika, Sb. 2, 1955, 3-93]. G. K. Mikhailov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**282. Felkel, K., Calculation of the unsteady flow in open channels** (in German), *Bautechnik* **35,** 6, 216-223, June 1958.

Author gives a graphical-analytical procedure by means of which it is possible to define quickly and easily the positions reached by the water levels in a process of unsteady flow which arises in an adduction or discharging channel of a hydroelectric power plant when the effluent discharge $Q_e$ is different from the incoming discharge $Q$.

Author examines first the process of unsteady flow which establishes itself in a channel when the emptying (or filling) lasts several hours after the wave motion caused by the sudden variation of flow is extinguished. With reference to experiences carried out by himself on the Rems River, author assumes that the flow profiles corresponding to successive instants $\Delta T$ be at a constant distance $\Delta t$, at least within short channel sections.

He assumes, moreover, that the surface profiles do not differ appreciably from those corresponding to conditions of steady flow; to draw such profiles, author makes use of the procedure proposed by Werner, substantially coincident with the Grimm method.

$J_0$ and $Q_0$ being, respectively, the water-surface slope and the discharge corresponding to uniform flow conditions, in a section of abscissa $x$ the surface slope $i$ corresponding to discharge $Q_x$ is given by $i = k\,Q_x^2\,J_0/Q_0^2$, where $k$ is a coefficient that in a subcritical flow can be put = 1.

The flow profiles during the process of unsteady flow are determined on the basis of an assigned law for the discharges $Q_x$ in the sections of abscissa $x$.

From the flow profiles the values $\Delta t$ in each stretch, and as a consequence the values $\Delta T$, are deduced from the equation: $\Delta T = \Delta w/(Q_a - Q_e)$, $\Delta w$ being the volume enclosed by two flow pro-

files corresponding to successive instants $\Delta T$. The discharge $Q_x$ computed as a first approximation is verified by means $Q_x = Q_a - (Bx/\Delta t)$, $B$ being the width in the surface of the current. If a difference is found the trial is repeated introducing the new value of $Q_x$.

Author extends the application of the method to the computation of flow-profile following the surge caused by sudden opening or closing operation of the plant.

Author exemplifies the application of the method with numerical computations and suggests useful simplifications to adopt in the calculations.

Reviewer is of the opinion that the calculation procedures suggested by the author are very useful in practical applications.

A. Russo Spena, Italy

**283. Babcock, H. A., Tabular solution of open channel flow equations,** *Proc. Amer. Soc. Civ. Engrs.* **85,** HY 3 (*J. Hydr. Div.*), 17–24, Mar. 1959.

This paper presents and explains a table by which cubic equations which arise in open channel flow problems may be solved without the tiresome trial and error method usually necessary.

Use of the table is limited to the special case of rectangular channels.

From author's summary

**284. Gogolev, V. M., Approximate calculation for the flow of a liquid in a channel** (in Russian), *Vestn. Leningr. In-ta* no. 1, 197–200, 212–213, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6611.

The problem is examined of the determination of a steady vortex-free motion of an ideal incompressible liquid in a curvilinear channel. By introducing an orthogonal system of curvilinear coordinates $q_1$, $q_2$ the problem leads to the search for the solution of a linear system of two differential equations with particular derivatives relative to projections $v_1$ and $v_2$ of the velocity of the liquid onto the ortho positions of the coordinate lines $q_1$ and $q_2$. As boundary conditions, which have to satisfy the sought functions $v_1$ and $v_2$, conditions are adopted for a continuous flow past the boundaries of the channel, and some other conditions at the entry and exit of the channel. The system obtained is converted to new dimensionless magnitudes and is replaced by a system, ranking as its equivalent, of integral equations of the Volterra type. To solve the latter the method of successive approximations is used. The arbitrary constants obtained thereby are selected from the condition of the best approximation to the given conditions at the entrance and exit to the channel. As an example a case is calculated for the flow of the liquid in the channel, spreading to an infinite distance on both sides. The results of these calculations are compared with the precise solution obtained for the identical case by means of the method of characteristics. The comparison shows satisfactory convergence of the approximate and exact solutions as early as at the second step of approximation. Author points out that the proposed method can be developed to include the case of a compressible liquid.

G. N. Pyikhteev

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**285. Zhavoronkov, N. M., and Nikolaev, A. M., Determination of the eddy viscosity of the turbulent stream in a channel of the rectangular cross section** (in Russian), *Trudĭ Kazansk. Khim. Tekhnol. In-ta* no. 21, 171–193, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 834.

Authors split the stream into three zones to investigate the distribution of velocities in the cross section of a stream flowing in a rectangular channel: the laminar sublayer, the intemediate layer, and the turbulent nucleus. Equations are obtained for the distribution of velocities and for the coefficient of the eddy viscosity in these three zones.

E. M. Minskii

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**286. Drobot, S., and Rybarski, A., A variational principle of hydromechanics,** *Arch. Rational Mech. Anal.* **2,** 5, 393–411, Feb. 1959.

Variational principles leading to the partial differential equations of hydrodynamics involve side conditions for which the authors seek a better motivation than the success of a formal derivation of the equations of motion. This is achieved by introducing a general formulation of the requirement that mass be unaltered by the variations to be allowed, which are consequently described as hydromechanical variations. Finally, the form of the Lagrangian to be used is justified by the Galilean invariance of the action integral.

P. R. Garabedian, USA

**287. Hendriks, L., Direct analytic calculation of pressure pipelines, etc. by means of the formula of Colebrook-White** (in Dutch), *Ingenieur* **70,** 51, B.283–B.284, Dec. 1958.

The formula of Colebrook-White is difficult to handle in practice, as the coefficients $\lambda$ and $C$ of Darcy and de Chezy are implicit therein. To simplify the calculations as much as possible, the Stanton diagram can be used, or the graph of J. Th. Thijsse. By means of the Stanton diagram, several graphs and nomograms have been composed, with which the calculation of pressure pipelines and suchlike can be done very quickly. The definition of the so-called roughness of sand $k$ on existing pressure pipelines, however, must still be established by experiment.

In this paper, the formula of Colebrook-White is combined with the formulas of Darcy and de Chezy, and by means of these it is possible to carry out the calculation by direct analysis.

From author's summary

**288. Kharlamov, P. V., A general case of the integrational capacity of Kirchoff's equations** (in Russian), *Trudĭ Donetsk. Industr. In-ta* **20,** 5–9, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6285.

The general case is investigated of the motion of a body in a liquid in a flow free from vortex action. Kirchoff equations are derived in the central axes. For one special case of the motion author finds a fourth integral, permitting a solution to be obtained in terms of quadratics. It is shown how these quadratics can be calculated.

N. N. Moiseev

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**289. Filatov, A. N., Spiral streams in an unbounded space** (in Russian), *Izv. Akad. Nauk UzbSSR, Ser. Fiz.-Matem. Nauk* no. 2, 5–19, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5320.

The problems are investigated of the stationary spiral motion of an ideal liquid in an infinite space. As regards the case of the incompressible liquid the vector velocity is satisfied by the equations

$$\text{rot } v = \lambda v, \quad \text{div } v = 0$$

where $\lambda$ is some scalar function. By using the known method for the determination of velocity by the given vortex in an infinite space, author obtains for $v$ a homogeneous integral equation with a triple multiple integral in the infinite space and substantiates the theorem: that if the velocity to infinity diminishes no less quickly than $1/R^3 (R \longrightarrow \infty)$ then there are no spiral motions when $\lambda =$ const. The theorem is generalized to also include the case of an ideal barotropic liquid. The equations below are then examined

$$\text{rot } v = kv + \omega, \quad \text{div } v = 0 \qquad [1]$$

where $k$ is a constant, $\omega$ and $\theta$ are given functions. The uniqueness of $v$ is substantiated with a delimited $|vR^{2+\mu}|$, $0 < \mu < 1$ and the solution of system [1] is brought into a heterogeneous integral equation with delimited

$$|vR^{2+\mu}|, \ |\omega R^{2+\mu}|, \ |\theta R^{2+\mu}|$$

The solution of the obtained integral equation is derived in a clear fashion. The paper concludes with a generalization of the obtained results to cover the system of equations of type [1]

D. E. Dolidze

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**290. Smith, R. A., Calibration of a submerged broad crested weir,** *Proc. Amer. Soc. Civ. Engrs.* **85,** HY 3 (*J. Hydr. Div.*), 1-16, Mar. 1959.

This work is different from previous publications on the problem in that it treats the calibration, or correlation of variables, even though the weir is completely submerged and tailwater phenomena control the discharge. Previous writings treat the calibration for the condition of free over-fall, but for the submerged condition, the discharge coefficients were shown to vary over a wide range in unpredictable fashion. This paper shows that for free over-fall the discharge is a function of the head on the weir, but for the submerged condition the discharge is a function of the degree of submergence. After calibration, the computed discharge, when compared with the observed discharge, showed a probable deviation of approximately 2%. From author's summary

**291. Strasberg, M., Onset of ultrasonic cavitation in tap water,** *J. Acoust. Soc. Amer.* **31,** 2, 163-176, Feb. 1959.

The conditions influencing the onset of acoustically-induced cavitation in tap water have been investigated, with special attention to the effect of air-filled cavitation nuclei. Cavitation was induced by exciting an acoustic radial mode in the water in a spherical resonator at a frequency near 25 kc/sec. Air-filled nuclei were detected by observing the reverberant decay of sound in the resonator at frequencies from 150 to 550 kc/sec, the presence of air nuclei causing an increase in the decay rate.

Measurements have been made of the sound pressure required for cavitation inception, and of the content of air nuclei, for the following treatments of the water: (1) allowing the water to stand undisturbed after drawing from the tap, (2) partially deaerating the water, and (3) subjecting the water to increased static pressure. Some measurements were also made of the threshold for rectified diffusion into air bubbles.

The experimental results have been compared with theoretical predictions based on three alternate forms of air nuclei: (1) free air bubbles, (2) air trapped in cracks on suspended solid particles, and (3) air bubbles surrounded by skins of organic impurities.

From author's summary

**292. Gigiberia, G. Va., Problems of the hydraulics of air occlusion** (in Russian), *Trudí In-ta Energ. Akad. Nauk GruzSSR* **10,** 67-78, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Ref. 874.

Author obtains the speed of air occlusion in the inclined delivery conduit on the basis of the Hamilton principle of the least action, erroneously treating the force of the circumventing water resistance against air occlusion as some kind of motion while the speed can be obtained by a simple equalization of this resistance force to the projection of lifting force on the pipe axis. Author's formula in the result contains initially an erroneous numerical coefficient which, however, in the final transformations disappears automatically due to the introduction of numerical values for coefficients which are calculated from experimental data for pipes with diameters of 54 and 45 mm. Inaccuracy of the theoretical composition (for example, determination of a length of the air occlusion as the ratio of its volume to the central cross-sectional area) and the scarcity of experimental cases make the results difficult to use for other conditions. N. A. Kartvelishvili

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

# Incompressible Flow

(See also Revs. 282, 351, 375, 534)

**293. Kemp, N. H., Vorticity interaction at an axisymmetric stagnation point in a viscous incompressible fluid,** *J. Aero/Space Sci.* **26,** 8, 543-544 (Readers' Forum), Aug. 1959.

The purpose of the present note is to give an exact solution of the incompressible Navier-Stokes equations at an axisymmetric stagnation point with vorticity in the oncoming flow which varies linearly with distance from the axis. This solution has application to the hypersonic axisymmetric blunt body problem, for which Lighthill has shown the vorticity in the inviscid shock layer is very nearly of this form. From author's summary

**294. Kynch, G. J., The slow motion of two or more spheres through a viscous fluid,** *J. Fluid Mech.* **5,** 2, 193-208, Feb. 1959.

Series solutions of the Navier-Stokes equations with inertia terms neglected are obtained for two spheres acted on by external forces. The spheres need not be equal in diameter nor very far apart. Theoretical values of velocity of fall of equal spheres with various inclinations of the line of centers with the horizontal are in fair agreement with measured velocities. Theoretical formula for velocity of two spheres is extended to more than two particles and is used as basis for discussion of motion of three particles. Comments are made concerning calculation of sedimentation velocities with small concentrations of particles.

N. Tetervin, USA

**295. Van Rossum, J. J., Viscous lifting and drainage of liquids,** *Appl. Sci. Res.* (*A*) **7,** 2/3, 121-144, 1958.

**296. Gofman, A. D., Question of the role of boundary conditions when modelling the motion of a solid body in an incompressible viscous liquid** (in Russian), *Trudí Tsentr. N.-i. In-ta Morsk. Flota* no. 7, 96-102, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2961.

**297. Narasimhan, M. N. L., On the steady laminar flow of a viscous liquid through an elastic tube with constant temperature gradient,** Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956, 153-164.

Author uses method of successive approximations, beginning with a parabolic velocity distribution and using this distribution, to calculate second-order terms and hence get a more accurate estimate of the velocity distribution. Two forms of revised velocity distribution are obtained, one from the equations of motion and one from the energy equation. Reviewer feels that the former is correct, and that the energy equation should be used only for calculating temperature distribution and not velocity. Doubt is thus cast on the author's conclusion that, with viscous fluids, heat transfer makes the tube swell in the direction of the flow.

There are several misprints, and the journal title is omitted from one of the references. J. F. Davidson, England

**298. Moore, W. L., Relationships between pipe resistance formulas,** *Proc. Amer. Soc. Civ. Engrs.* **85,** HY 3 (*J. Hyd. Div.*), 25-41, Mar. 1959.

The relationship between modern concepts of pipe resistance and the older empirical formulas is clarified, and a simple procedure developed to derive an exponential formula applicable to a known range of flow conditions. The analysis makes apparent the range of flow conditions for which any particular exponential formula is applicable. Limitations of the equivalent pipe concept are discussed. Data on resistance measurements in water mains in service indicate that the head loss varies with the discharge to a power nearly equal to 2.0 rather than 1.85 as commonly assumed.

From author's summary

**299. Ting, L., On the mixing of two parallel streams,** AFOSR TN 58-628 (Polyt. Inst. Brooklyn, Aero. Lab. Rep. 441; ASTIA AD 162 158), 26 pp., July 1958.

Using the techniques of boundary-layer theory, the proper third boundary condition for the mixing of two parallel streams is derived from the compatibility condition of the higher order approximation. It is shown that the commonly adopted third boundary condition of balancing of transverse momentum is correct only for the mixing problem of two semi-infinite incompressible streams. For the fulfillment of the proper third boundary condition, the possibility of introducing the similar solution of Blasius type is examined for various cases. From author's summary

**300. Yih, C.-S., On the flow of a stratified fluid,** Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 857-861.

Author considers the steady flow of a stratified liquid with a linear vertical density distribution at infinity. An "associated flow" is defined by introducing a modified stream function which permits an exact solution to the problem. An example is worked concerned with a line sink at the bottom of a horizontal channel. As a result, a critical Froude number is obtained such that separation of portions of the liquid is impossible when the critical number is exceeded. R. B. Banks, USA

**301. Konovalov, I. M., The field of velocities around a plate in a plane flow field** (in Russian), *Trudī Leningr. In-ta Inzh. Vodn. Transp.* no. 22, 3-10, 1957; *Ref. Zh. Mekh.* no. 6, Rev. 6815.

Author proposes to calculate the field of velocities near a plane plate and its wake in a plane flow field on the basis of the solution, by the method of sources, of the equation for motion, reduced to the form of

$$\frac{\partial(\nu^2)}{\partial(x^2)} = a^2 \frac{\partial^2(\nu^2)}{\partial y^2}$$

(The reduction of the equation of motion to the recorded equation of the heat-conductivity type was proposed earlier by the author, and is based on the insecurely founded assumption that the coefficient of turbulent viscosity is proportional to the local mean velocity $\nu$ and the longitudinal coordinate $x$.) The solution for the flow above the plate is examined also for the case when $a = a(x)$. A method is proposed for the determination of the value $a$ by means of the coefficient of resistance of the plate. The flow about a surface of small curvature is examined on the basis of the solution of the equation of the same type for a straightened-out surface, taking into account the pressure gradient calculable from the condition of the potential flowing about a distorted plate. A comparison of the solutions examined with the measurements made is not forthcoming. There are some misprints.

B. A. Fidman
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**302. Borisenko, A. I., The flow past a hydrodynamical grid of elliptical cylinders** (in Russian), *Sb. Trudī Labor. Gidravl. Masbin., Akad. Nauk USSR* no. 6, 59-73, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5349.

An integral equation is derived and solved regarding the distribution of vortices on the contours of ellipses in a grid of elliptical cylinders, flown past by a plane steady potential stream of an incompressible liquid. The solution was arrived at by the method of resolution into series, a method employed earlier by the author to cover the case of a grid of round cylinders [*Sb. Trudī Labor. Problem Bystrokhodnykh Masbin i Mekhanizmov Akad. Nauk USSR* no. 4, 39-67, 1953]. Solutions of the problem by another method are known [D. A. Voitashevskii, "Calculations and investigations of hydrodynamic grids," Gos. N.-Tekhn. Izd-vo Mashinostroit. Lit-ry, Moscow, 1953]. G. Yu. Stepanov
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**303. Legchenko, I. G., Flow of the surface air stream over an obstacle in the form of elliptical half-cylinder and through a uniform air intake** (in Russian), *Trudī Novosibir In-ta Zh.-D. Transp.* no. 12, 136-148, 1955; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 559.

The Poisson equation, with right-hand side constant, for a plane-parallel motion of the ideal noncompressible gas is solved in the elliptical coordinates by the aid of Galerkin's method. The approximate solution of the problem is compared with the known Chaplygin solution of the turbulent flow over a plate.

N. A. Slezkin
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**304. Smith, A. G., On the generation of the streamwise component of vorticity for flows in rotating passages,** *Aero. Quart.* **8,** 4, 369-383, Nov. 1957.

**305. Moore, D. W., The flow past a rapidly rotating circular cylinder in a uniform stream,** *J. Fluid Mech.* **2,** 6, 541-550, Aug. 1957.

**306. Tsuyama, M., and Taga, M., On the flow of the air-water mixture in the branch pipe, Part I: Experiment on the horizontal branch pipe which is equal to the main one in diameter,** *Bull. JSME* **2,** 5, 151-156, Feb. 1959.

Authors experimented on flow patterns, distribution of quantity, especially loss of head at a cross-branch section by flowing air-water mixtures into a horizontal branch pipe of 23.4-mm diam. They carried out the investigation from the following two viewpoints:

(1) $\xi_{b_1}$, loss of energy attributable to the branch only;

(2) $\xi_{b_2}$, loss of energy including the effect of the irregularity of the stream past a branch section.

In consequence, it was possible for them to make the characteristics of the loss of energy comparatively clear. Then they discovered that the coefficient of loss of head $\xi_{b_2}'$ was approximately proportionate to the ratio of energy at the main flow and the branch flow. From authors' summary

## Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 26, 28, 172, 337, 338, 345, 351, 353, 355, 385, 386, 414, 416, 465, 467, 485, 488, 495, 543)

**307. Inman, R. M., A note on the skin-friction coefficient for compressible Couette flow,** *J. Aero/Space Sci.* **26,** 3, p. 182 (Readers' Forum), Mar. 1959.

A result of Liepmann and Roshko ["Elements of gasdynamics," p. 305, Wiley, 1957; AMR **10** (1957), Rev. 3689] on the skin-friction coefficient in compressible Couette flow is generalized to include the effect of heat transfer. K. Stewartson, England

**308. Ting, L., Solutions of supersonic interference problems by generalized integral relationship—examples for a circular cylindrical body,** AFOSR TN 58-1069 (Polyt. Inst. Brooklyn, Aero. Lab. Rep. 465; ASTIA AD 207 229), 43 pp., Oct. 1958.

A procedure is given for treating wing-body combinations involving cylindrical bodies of arbitrary cross section. The surface

pressure distribution inside the interference region is represented by a linear combination of a finite number of elementary functions of the surface variables. The arbitrary constants are determined from integral relationships which are reduced to a set of simultaneous linear algebraic equations and satisfy the condition of continuous pressures in the interference region. The calculated results for a circular cylindrical body, using eight terms in the wing and body pressure distributions, show good agreement with the wing pressures predicted by the quasi-cylindrical theory of Nielsen [NACA Rep. 1252]. A. H. Sacks, USA

**309. Godunov, S. K., The singularity of solution of hydrodynamical equation** (in Russian), *Matem. Sb.* **40**, 4, 467–478, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 297.

The singularity of solution is examined of the system of nonlinear equations of gas dynamics

$$\frac{\partial u}{\partial t}+\frac{\partial p(v,E)}{\partial x}=0, \qquad \frac{\partial v}{\partial t}-\frac{\partial u}{\partial x}=0,$$

$$\frac{\partial (E+\tfrac{1}{2}u^2)}{\partial t}+\frac{\partial pu}{\partial x}=0 \qquad [1]$$

with discontinuities. First, the theorem of singularity is proved for the general linear system

$$\frac{\partial u}{\partial t}-\frac{\partial [A(x,t),v]}{\partial x}=0, \qquad \frac{\partial v}{\partial t}-\frac{\partial u}{\partial x}=0 \qquad [2]$$

with the positive coefficient $A$, which has discontinuity lines within the examined range $t \geqslant 0$, which is limited by a segment of a straight line and by the arc $\Gamma_2$, which fulfils some conditions. The theorem of the singularity of Eq. [2] for chosen values of $u$, and $v$ at the segment $t = 0$ is proved by supposition of existence of the continuous solution of the conjugate system in which $\Gamma_2$ changes continually and is expressed in some way by $u$ and $v$. Conditions at which the conjugate function has a solution are deduced, giving at the same time conditions of singularity of the solution of the system [2].

Utilizing the conditions of singular solution of the system [2], author examines the singularity of the solution of the nonlinear system

$$\frac{\partial u}{\partial t}+\frac{\partial p(v)}{\partial x}=0, \qquad \frac{\partial v}{\partial t}-\frac{\partial u}{\partial x}=0 \qquad [3]$$

converting it to the linear system by the well-known Adamar's method, and then showing a possibility of expansion of the proof of singularity of the solution of system [3] on system [1].

Author remarks that the conditions of singularity obtained by him are equivalent to the condition

$$\int_C S dx \leqslant 0$$

where $C$ is an arbitrary closed contour and $S$ is entropy.

D. E. Dolidze

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**310. Bulakh, B. M., Regions of convergence of series which form the solution of some problems concerning axial symmetrical flow of gas** (in Russian), *Ucb. Zap. Sabatovsk. In-ta* **52**, 3–8, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 300.

A solution is given of the Cauchy problem for a system of two quasilinear equations of the first order describing a laminar isoentropic flow of gas, with starting data on the symmetry axis.

The construction of key functions is given for plane and axisymmetrical problems. The range of convergency is established for series giving a solution of these functions.

V. K. Solodkin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**311. Schmidt, W., Flow data for a three-parameter system of half bodies of revolution in sonic flow and in linearized supersonic flow** (in German), *Dtsch. Versuchsanstalt Luftfahrt Ber.* **70**, 42 pp., Aug. 1958.

Bodies considered have pointed noses and zero derivative of cross-sectional area at the base. The longitudinal distribution of cross-sectional area is represented as a sixth degree polynomial in which the parameters are essentially the volume, the nose angle and the curvature of a meridional curve at the base.

For case $M_\infty = 1$ flow is determined using approximation of Oswatitsch and Keune [AMR **10** (1957), Rev. 1160]. Also author shows that, for these bodies, theory yields drag coefficient at $M_\infty = 1$ as half that for $M_\infty > 1$ determined from linearized theory of supersonic flow. Values of parameters are then found for body of minimal drag. H. C. Levey, Australia

**312. Kopylov, G. N., On similarity of transonic plane flows,** *Appl. Math. Mech. (Prikl. Math. Mekh.)* **22**, 3, 540–548, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Author discusses choice of Mach number dependent coefficient for nonlinear term in transonic differential equation with a view of arriving at best possible approximation to flow in neighborhood of the sonic line. He concludes that $1/2 + (\gamma + 1/2)\, M_\infty^2$ is to be referred to the value $(\gamma + 1)\, M_\infty^2$ proposed by Spreiter [AMR **8** (1955), Rev. 1104]. Conclusion is supported by comparison with a number of known experimental and theoretical results. Spreiter's value is shown to be better, possibly, when shocks are important.

S. B. Berndt, Sweden

**313. Ryzhov, O. S., On gas flow in Laval nozzles,** *Appl. Math. Mech. (Prikl. Math. Mekh.)* **22**, 3, 549–553, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

A family of simple analytic solutions of the transonic differential equation is shown to describe a variety of three-dimensional flows in nozzle throats. Earlier known solutions for plane and axisymmetric flows form particular examples.

S. B. Berndt, Sweden

**314. Dorfman, A. Sh., Computation of a Laval nozzle,** *Appl. Math. Mech. (Prikl. Mekh.)* **22**, 3, 554–561, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Coefficients of the hodograph equations for plane gas flow depend in a complicated manner on local Mach number. By approximating this dependence in a simple yet efficient way author obtains simple approximate solution for flow in supersonic part of a nozzle (up to where $M \simeq 1.5$). Solution is shown to be continuation of known solution for the subsonic part and thus permits analytic construction of the complete initial portion of two-dimensional supersonic nozzles. S. B. Berndt, Sweden

**315. Truckenbrodt, E., Application of the similarity rules of compressible flow for three-dimensional airfoil theory** (in German), *Z. Flugwiss.* **5**, 12, 341–346, Dec. 1957.

The Prandtl-Glauert-Ackeret similarity rules of sub- and supersonic flows as well as Karman's rule of transonic flow have been derived on the ground of the partly linearized equation for velocity potential of compressible flow. Application of these rules for three-dimensional problems of wing theory is shown. Simple connections are given between pressure-distribution, forces and

moments of the wing on one side and incidence angle, geometric data of the wing and of the profile on the other.

From author's summary by W. Prosnak, Poland

**316. Yoshihara, H., On the flow over a finite wedge in the lower transonic region,** *J. Aero. Sci.* **24,** 9, 661–666, Sept. 1957.

**317. Hausenblas, H., Supersonic flow at outlet bucket ring turbine blade** (in German), *Ing.-Arch.* **26,** 6, 411–415, Dec. 1958.

Author uses method of characteristics to determine the inviscid supersonic flow in the outlet-triangle and downstream of an acceleration cascade. This is done for (1) a straight-profile cascade and (2) a special cascade consisting of curved, thick profiles but with a sharp trailing-edge. The case of a thick trailing-edge and a one-dimensional approximation method are briefly discussed. This specialized problem is handled concisely and competently.

R. K. Sherburne, USA

**318. Tarasova, I. Z., Solution of boundary problems with compression jumps in a plane vortex motion of a supersonic flow of gas** (in Russian), *Uch. Zap. LGU* no. 217, 195–224, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6424.

Taking as her starting point the equation of the plane vortex motion of a gas for the function of a current $\Psi$ obtained by L. I. Sedov ["Plane problems in hydrodynamics," Gostekhizdat, 1950], author solves the boundary problems for the supersonic motions of an ideal gas with compression jumps. As was shown by I. Z. Kalishevich [*Doklady Akad. Nauk SSSR* **99,** no. 1, 1954] if it is assumed that entropy can be presented in the form $\delta(\Psi) = \bar{\delta} + \bar{\delta}(\Psi)$, where $\delta$ is a constant magnitude, and the square of the ratio $\bar{\delta}(\Psi)/\bar{\delta}$ can be disregarded by comparison with unity, then L. I. Sedov's equation merges with the linear equation and is capable of integration in a general form. Based on the solutions obtained by Kalishevich, the following problems are solved: the flowing past a solid wall combined with a compression jump during an irregular inflowing current and an even inflowing current; the boundary problem for a space delimited by lines of strong disruption and two characteristics, during irregular and even inflowing currents. The solution of the problems leads to a numerical integration of systems of differential equations which appear to be somewhat unwieldy.

M. P. Mikhailova

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**319. Germain, P., Determination of optimum shape of an airfoil in supersonic flow** (in French), *Rech. Aéro.* no. 60, 3–12, Sept.-Oct. 1957.

The present article contributes to the problem of the supersonic airfoil operating at conditions of minimum drag under various conditions of restraint. The problem is to supply a method for specifying the shape of the wing, if the optimum exists. From the mathematical point of view the problem is not "well set" and the solution emerges as a solution to the problem of moments. Nevertheless, to show the applicability of the method, a complete study is made of certain problems relative to a wing of elliptic planform. From this study one recovers the results obtained by R. T. Jones by an altogether different method.

From author's summary by H. A. Stine, USA

**320. Adamson, T. C., Jr., and Nichols, J. A., On the structure of jets from highly underexpanded nozzles into still air,** *J. Aero/Space Sci.* **26,** 1, 16–24, Jan. 1959.

Locations of both the initial normal shock and the jet boundary are considered. For sonic exit conditions a model based upon shock location yielding ambient pressure distribution downstream is in agreement with experimental data. Extension to supersonic exit flow is made by assuming that downstream of the exit rhombus the pressure distribution is identical to that for the sonic exit case. Again experimental comparisons are good. Accurate boundary position predictions are shown to be limited to low $M$ and pressure distributions.

J. R. Baron, USA

**321. Lovey, H. C., The thickness of cylindrical shocks and the PLK method,** Aero. Res. Lab. Melbourne, Austral., Rep. A.108, 27 pp., Jan. 1958.

After a detailed analysis of the iso-energetic radial two-dimensional flow of a viscous heat-conducting gas, author finds that the cylindrical shocks which occur in this case have a thickness of order $Re^{-1}S^{-1}\log(ReS^3)$, where $Re$ is the Reynolds number of the flow and $S$ is the shock strength. As this result does not agree with that obtained by using the Poincaré-Lighthill-Kuo (PLK) method, author submits the problem to a critical examination and concludes that the PLK method fails in this case and consequently cannot be considered as a "panacea" for all singular perturbation problems.

A complete mathematical theory of this powerful PLK method is at present lacking, and reviewer hopes that author's paper will incite such a study.

M. I. Ionescu, Roumania

**322. Belotserkovskii, O. M., Flow with a detached shock wave about a symmetrical profile,** *Appl. Math. Mech. (Prikl. Math. Mekh.)* **22,** 2, 279–296, 1958. (Reprint order no. PMM 23, Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

A method is given for computing the rotational flow field in the region behind a detached shock wave. The shape and location of the shock are obtained from the solution. The method consists of replacing the standard system of nonlinear partial differential equations by an approximating system of ordinary equations, the latter being solved on the high-speed computer of the Soviet Academy of Sciences.

As an example of the method, flow past a circular cylinder is computed for a range of incident Mach numbers. The positions of the shocks and the sonic lines are in good agreement with experimental results.

A. R. Mitchell, Scotland

**323. Bibosunov, I., An example of transonic flow of a gas with a supersonic zone, terminated by a curved shock which ends inside the flow,** *Appl. Math. Mech. (Prikl. Math. Mekh.)* **22,** 3, 431–441, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Flow is assumed irrotational on both sides of shock. Plane steady solution given is based on equations of Falkovitch [*Prikl. Mat. Mekh.* **10,** no. 4, 1946] in which variation of entropy and hence vorticity behind shock is neglected, which is permissible near sonic speed since jump in entropy is proportional to cube of jump in normal velocity. Work is sequel to that of Frankl [*Prikl. Mat. Mekh.* **19,** no. 4, 1955], who solved same type of problem with straight shock.

B. Bernstein, USA

**324. Sinani, I. B., Tourmaline indicators of shock waves in liquids** (in Russian), *Pribory i Tekhn. Eksperimenta* no. 4, 85–89, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4367.

Tourmaline indicators (transmitters) find their effective application in the measurement of impact waves. Author analyzes the indicators' error arising at the expense of the end velocity of the propagation of the shock waves on the transmitter's record, at the expense of the flow excitation by the transmitter and at the expense of the conversion of the mechanical magnitudes into electrical magnitudes and vice versa. The construction of indicators of various dimensions is described. The technology of manufacture of indicators is given in detail; this appears to be rather complex and difficult. Examples are furnished of the recordings of shock waves, their oscillograms being analyzed. The recordings were made by means of indicators, the tourmaline plates of which measured 0.5 × 0.5 mm, with the time of rating not exceeding twice

the time of flowing about the sensitive element of the transmitter and with an internal resistance of the order of $10^{11}$ Ohm. The natural interference of the indicator was evaluated at not more than 2% of the recorded amplitude. The shielding shell of the transmitter made its use possible in any liquid.

S. G. Popov
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**325. Guienne, P., and Bouniol, F., Determination of the flow field upstream of a detached shock wave with help of interferogram method** (in French), ONERA no. 53, 21–31, Sept.-Oct. 1956.

**326. Leonovich, K. M., The reciprocal relationship between the aerodynamics of gas blast flows and the technological constants of the process of underground coal gasification** (in Russian), *Podzemn. Gazifikatsiya Uglei* no. 1, 32–38, 1957; *Ref. Zh. Mekh.* no. 2, 1958; Rev. 1756.

The fundamental trends in the investigation of blower flows in the underground gasification of coal are discussed. Two principal conditions are laid down for the formation of combustible gases: (1) Repeated introduction of the gas blow to the reacting coal face; and (2) reduction in heat losses after the oxidizing reaction. The interrelationship is investigated between the aerodynamic activity of the blow gas flows, humidity of the gas, thermal conditions in the cycle, and calorific power of the gas.

V. D. Sokolov
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

## Boundary Layer

(See also Revs. 5, 30, 386, 403, 414, 465, 466)

**327. Squire, W., Application of generalized Gauss-Laguerre quadrature to boundary-layer problems,** *J. Aero/Space Sci.* **26,** 8, 540–541 (Readers' Forum), Aug. 1959.

This short note calls attention to the fact that Gauss-Laguerre quadrature can often be used to advantage for solving the laminar boundary-layer equation. Application to the equation for Blasius' boundary layer is illustrated. A. M. O. Smith, USA

**328. Hassan, H. A., A new solution to the laminar boundary-layer equations,** *J. Aero/Space Sci.* **26,** 3, 189–190 (Readers Forum), Mar. 1959.

Transformation of boundary-layer equations into a form permitting solution by series expansion in streamwise direction. Treatment is closely related to a paper by Görtler [*J. Math. Mech.* **6,** 1, 1957], but is applicable to a different class of outer pressure distributions. L. J. F. Broer, Holland

**329. Hassan, H. A., On heat transfer to laminar boundary layers,** *J. Aero/Space Sci.* **26,** 7, p. 464 (Readers' Forum), July 1959.

A method is given for calculating the local heat-transfer coefficient $h$ in a laminar boundary layer with constant properties under arbitrary pressure and surface temperature distributions. The method is based upon the author's solution of the boundary-layer equations [see preceding review]. A power series in powers of $\exp\left[-(1/\nu)\int U_\infty(x)dx\right]$ for $h$ is derived whose coefficients depend upon the coefficients in the series representation for the temperature in terms of universal functions. N. D. Kazarinoff, USA

**330. Nazarchuk, M. M., Method of solution for the internal problem in the theory of the boundary layer** (in Russian), *Dop. Akad. Nauk URSR* no. 2, 145–148, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6749.

Some fragmentary concepts are advanced in regard to the setting and the solution of the problem of the motion of a compressible viscous liquid in the initial portion of a smooth tube, to cover the cases of laminar and turbulent layers, by the single parameter method. The actual solution is not given, while the subject matter of the observations does not justify the deductions given in the paper's resumé.

L. G. Loitsianskii
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**331. Yu, Y.-S., Effect of transverse curvature on turbulent boundary-layer characteristics,** *J. Ship Res.* **2,** 3, 33–51, Dec. 1958.

Mean-velocity profiles are reported for the turbulent boundary layer on a long cylindrical body in axial flow. Values of $\delta/r_0$ are less than two ($\delta$ boundary-layer thickness, $r_0$ body radius) and effect of curvature on local friction coefficient is found to be small. Analysis of data is in terms of wall law and defect law, but results are not interpreted in terms of Reynolds numbers based on local quantities. Flat-plate data obtained in the same tunnel by the same techniques are available [AMR **12** (1959), Rev. 3494].

Reviewer wishes to direct attention to an unpublished paper which includes mean-velocity profile data at higher values of $\delta/r_0$ at low speeds as well as floating-element friction data at a Mach number of 5.8 [Richmond, R. L., "Experimental investigation of thick axially-symmetric boundary layers on cylinders at subsonic and hypersonic speeds," GALCIT, Hypersonic Research Project Memo. no. 39, June 20, 1957]. D. Coles, USA

**332. Willmarth, W. W., Space-time correlations and spectra of wall pressure in a turbulent boundary layer,** *NASA Memo* 3-17-59W, 22 pp., Mar. 1959.

Measurements of the statistical properties of the fluctuating wall pressure produced by a subsonic turbulent boundary layer are described. The measurements provide additional information about the structure of the turbulent boundary layer; they are applicable to the problems of boundary-layer induced noise inside an airplane fuselage and to the generation of waves on water.

From author's summary

**333. Ginoux, J. J., Experimental evidence of three-dimensional perturbations in the reattachment of a two-dimensional laminar boundary layer at M = 2.05,** AFOSR TN 59-169 (Training Center for Experimental Aerodynamics, Brussels, TN 1; ASTIA 211 148), 31 pp., Nov. 1958.

The reattachment of a laminar boundary layer after separation has been investigated at a Mach number of 2.05. Backward-facing step models were used that completely spanned the working section. Surface flow was observed by a sublimation technique and detailed spanwise surveys were made in the reattachment region of the flow with total head probes.

Strong, regular and repeatable spanwise perturbations were observed which could not be explained by irregularities either in the airflow upstream of the models or in the models themselves.

From author's summary

**334. Yasuhara, M., Simultaneous effects of pressure gradient and transverse curvature on the boundary layer along slender bodies of revolution,** *Aero. Res. Inst., Univ. Tokyo, Rep.* 335, 17 pp., Aug. 1958.

Probstein and Elliot [*J. Aero. Sci.* **28,** 3, 208-244, 1956; AMR **9** (1956), Rev. 2621] treated the transverse curvature effect on an axisymmetric compressible boundary layer by expanding the solution into a power series of a parameter which characterizes the ratio of the boundary-layer thickness to the body radius. They found similarity solutions possible for compressible flows without

pressure gradient or incompressible flows with pressure gradient. Author now shows that, assuming the viscosity coefficient to be proportional to temperature, the series expansion method can be extended to *certain* cases of compressible boundary layer with pressure gradient, when the outside flow is a small perturbation of either the uniform flow or the stagnation point flow. A special example satisfying author's compatibility requirement of body shape and outside flow is the subsonic flow over a slender parabolic body of revolution. Its calculation is carried out in detail to demonstrate the first-order effects of both the pressure gradient and the transverse curvature. S.-F. Shen, USA

**335. Plan, M., Methods of dynamic exploration and the study of the compressible boundary layer** (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4**, 184–195.

Results are reported of measured and theoretically calculated velocity profiles in compressible boundary layer over smooth flat plate with sharpened leading edge. Critical consideration is given to sources of error in use of stagnation pressure probes in bounday-layer measurements. Results with round and flattened probes are compared; far better agreement with theory is reported for use of round probes. Effect of probe size is reported and method of extrapolation to zero probe size is presented to produce "corrected" data showing close agreement with theory. Minute thicknesses of leading edge of test surface are reported to greatly affect boundary-layer thickness, surface stresses, and measurements of velocity profiles. Reviewer sees main value of the work in its condemnation of conventional flattened probes and in the method presented for determining effective center of finite round probes. W. Rice, USA

**336. Brun, E. A., and Plan, M., Methods of thermal exploration and study of the compressible boundary layer** (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4**, 196–200.

Data for the indicated stagnation-temperature profile in a compressible boundary layer over a sharp-edged, smooth, flat plate are presented and compared with theoretical distribution. In analogy with method for correcting measured pressure profiles to true values, presented by author in a companion paper, temperature data are corrected systematically to give excellent agreement with theoretical temperature distribution. Effects of plates of high and low thermal conductivity on the measured stagnation-temperature profiles are discussed; recovery factors for bare stagnation thermocouple are presented. Reviewer found paper much too brief to encourage use of authors' results and/or recommendations.
W. Rice, USA

**337. Nothwang, G. J., An evaluation of four experimental methods for measuring mean properties of a supersonic turbulent boundary layer,** *NACA Rep.* 1320, 11 pp., 1957.

See AMR **9** (1956), Rev. 3703.

**338. Moore, F. K., and Ostrach, S., Average properties of compressible laminar boundary layer on flat plate with unsteady flight velocity,** *NACA Rep.* 1325, 12 pp., 1957.

See AMR **10** (1957), Rev. 2204.

**339. Peterson, J. B., Jr., and Horton, E. A., An investigation of the effect of a highly favorable pressure gradient on boundary-layer transition as caused by various types of roughnesses on a 10-foot diameter hemisphere at subsonic speeds,** *NASA Memo* 2-8-59L, 32 pp., Apr. 1959.

Tests were conducted at Reynolds numbers up to $10 \times 10^6$ and at a maximum Mach number of about 0.1 which show that the occurrence of transition behind three-dimensional particle types of roughness could be correlated with the roughness Reynolds number. Results of tests with two-dimensional types of roughness are presented which show the effects of wire and scratch types of roughness on transition. Also included in the investigation were studies of the spread of turbulence behind a single roughness particle and the effects of holes such as pressure orifices on boundary-layer transition. From authors' summary

**340. van Driest, E. R., and McCauley, W. D., The effect of controlled three-dimensional roughness on boundary layer transition at supersonic speeds,** AFOSR TN 58-176 (North American Aviation, Inc., Missile Div. MD 59-115; ASTIA 152 209), 50 pp., Nov. 1958.

Experiments were performed in the 12-inch supersonic wind tunnel of the Jet Propulsion Laboratory of Caltech to investigate the effect of three-dimensional roughness elements (spheres) on boundary-layer transition on a 10-degree (apex angle) cone with zero heat transfer. Data were obtained at local Mach numbers of 1.90, 2.71, and 3.67 by varying trip size, position, spacing, and Reynolds number per inch. The results indicate that (1) transition from laminar to turbulent flow induced by three-dimensional roughness elements begins when the double row of spiral vortices trailing each element contaminates and breaks down the surrounding field of vorticity, (2) transition appears rather sudden, becoming more violent with increasing roughness height relative to the boundary-layer thickness, (3) after the breakdown of the vorticity field, the strength of the spiral vortices may still persist in the sublayer of the ensuing turbulent flow, (4) lateral spacing of roughness elements has little effect upon the initial breakdown (contamination) of the laminar flow, and (5) the trip Reynolds number $(uk/\nu)_g$, where $u$ and $\nu$ are the velocity and kinematic viscosity at the outer edge of the boundary layer and $k$ is roughness height, such that transition occurs at the roughness position, varies as the position Reynolds number to the one-fourth power, viz., $(ux_k/\nu)_g^{\frac{1}{4}}$, where $x_k$ is trip position.
From authors' summary

**341. Eichelbrenner, E. A., and Michel, R., Observations of laminar-turbulent three-dimensional transition** (in French), *Rech. Aéro.* no. 65, 3–10, July–Aug. 1958.

The methods for studying transition in tri-dimensional flow are according to the "prevalence" principle, which is defining the boundary layer from one coordinate normal to the surface, and the external flow as bi-dimensional with potential and flow lines as coordinates.

Michel's criterion for transition is defined from a Mangler generalized transformation applied to a stream tube, the reference length being locally chosen, so the Reynolds number remains unchanged along a stream line.

Then if we take as a constant an amplification rate for the most critical frequency in the boundary layer, we may define only one relation between the Reynolds number along the stream line and the Reynolds number based on momentum thickness in boundary layer. The experiments with ellipsoids in incidence show that the calculations are verified on upper and under side, but the transition on lateral side appears nearer the leading edge.

This phenomenon is explained by the transversal curvature of the stream lines under the influence of a pressure gradient. This was studied by Owen and Randall who gave a criterion similar to Michel's for the transversal stability of boundary layer. Nevertheless, it is important in this case to choose carefully the boundary-layer profile which Pohlhausen has represented by a third-degree polynome for the transversal velocities.

Owen's criterion seems to be verified when the transversal profile is represented by a fourth-degree polynome on the lateral sides of an inclined ellipsoid. In this case, the visualization shows that the sum of the two criteria, longitudinal (Michel's) and transversal (Owen's with transversal profile of fourth degree), are well represented by calculations. E. A. Brun, France

**342. Bruniak, R., Separation of boundary layer caused by compressible shock** (in German), *Öst. Ing.-Arch.* **11**, 3, 243–246, Nov. 1957.

The author makes the questionable assumptions that across the boundary layer on either side of a shock the pressure and stagnation temperature are constant though different. The Pohlhausen momentum equation and the shock jump conditions at the boundary-layer edge are then used to relate the pressure gradient parameter downstream to its value upstream and thus to estimate the chances of separation. A. F. Pillow, Canada

**343. Wintemitz, F. A. L., and Ramsay, W. J., Effects of inlet boundary-layer on pressure recovery in conical diffusers** (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2**, 439–458.

A novel method of generating specific boundary-layer conditions by means of projecting annular screens has been applied to diffuser research. It was possible to modify the velocity distribution substantially and to produce velocity profiles with inflections.

By comparison with approach length results, and on the basis of equivalent momentum thickness, it could be proved experimentally that a 20% variation in the inlet shape parameter did not significantly affect either the pressure recovery in the diffuser or the diffuser losses.

Diffuser efficiency and the terms describing diffuser effectiveness depend on the momentum thickness at inlet which, irrespective of the inlet velocity distribution, emerges as the controlling parameter. Area ratio diffuser angle and surface texture were constant in the experiments. Under these conditions, the controlling influence of $\theta/D_0$ extends to the momentum thickness formation, the velocity distribution, and thus the shape parameter at exit of the diffuser.

The presence of the screen rings is believed to have delayed the onset of separation. From authors' summary

**344. Spronck, R., Synthesis of the laws of two and three dimensional skin-friction** (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2**, 283–295.

**345. Lam, S. H., and Crocco, L., Note on the shock-induced unsteady laminar boundary layer on a semi-infinite flat plate,** *J. Aero/Space Sci.* **26**, 1, 54–56 (Readers' Forum), Jan. 1959.

This note condenses material which would deserve a paper. The laminar boundary layer on a flat plate is calculated when the surrounding gas with $P_r = \mu c_p/k$ = constant is set in motion by a plane shock wave moving along the flat plate.

The solution is given in terms of an integrodifferential equation with the shock strength $A = U/u$ ($U$ shock velocity, $u$ gas velocity behind the shock) as a parameter. So far, calculations, which presented some convergence difficulties, have been carried out for the special case of $A = \infty$ only, which is mathematically equivalent to the impulsive motion from rest of a semi-infinite flat plate treated by Stewartson [*Quart. J. Mech. Appl. Math.* **4**, no. 2, June 1951; AMR **5** (1952), Rev. 487].

H. P. Eichenberger, USA

## Turbulence

(See also Revs. 331, 332, 337, 408, 531, 546)

**Book—346. Kolmogorov, A. N., Obuchow, A. M., Jaglom, A. M., and Monin, A. S., Collection of papers on statistical theory of turbulence [Sammelband zur Statistischen Theorie der Turbulenz]**, Berlin, Akademie-Verlag, 1958, 228 pp. DM 25.50.

Book contains German version of thirteen fundamental theoretical papers on statistical theory of turbulence, published by the authors during the period 1941 to 1954 in Russian periodicals. They are: Obuchow, Statistical description of continuous field (1954); Jaglom, Homogeneous and isotropic turbulence in a viscous compressible fluid (1948); Kolmogorov, The local structure of turbulence in incompressible viscous fluid for very large Reynolds numbers (1941); Kolmogorov, Dissipation of energy in locally isotropic turbulence (1941); Obuchow, On the distribution of energy in the spectrum of turbulent flow (1941); Obuchow and Jaglom, The microstructure of turbulent flow (1951); Obuchow, Structure of the temperature field in turbulent flow (1949); Jaglom, On the local structure of the temperature field in turbulent flow (1949); Kolmogorov, On degeneration of isotropic turbulence in an incompressible viscous fluid (1941); Kolmogorov, On the disintegration of drops in turbulent flow (1949); Obuchow, On the effect of slight inhomogeneity of atmosphere on the spreading of sound and light (1953); Obuchow, Investigation of microstructure of winds in the lowest layer of atmosphere (1951); Monin and Obuchow, Fundamental legitimacy of turbulent mixing in the lowest layer of atmosphere (1954).

The first article of Obuchow presents the fundamental consideration on the statistical method applied to the scalar and vector fields of continuous medium. The subsequent nine articles, all concerned with the structure of homogeneous turbulence, are those already well known by the reference, for example, in Batchelor's book "The theory of homogeneous turbulence." The last three articles by Obuchow and Monin are concerned with the problems of atmospheric turbulence.

Book is valuable as the reference work of Soviet contribution to the statistical theory of turbulence, expecially because the original papers are rather difficult of access. I. Tani, Japan

**347. Craya, A., Contribution to the analysis of the turbulence associated with mean velocity** (in French), *Publ. Sci. Tech. Min. Air, France* no. 345, 111 pp., Aug. 1958.

Paper concerns the anisotropic structure taken by the homogeneous turbulence due to the presence of a field of linearly distributed mean velocities. First chapter establishes the dynamical equations of the double correlations at two points and of the triple correlations at three points. By applying the Fourier transform, the spectral tensor of the double correlations and that of the triple correlations are put into evidence. Second chapter analyzes the form of the spectral tensors when the fluid is an incompressible one. Together with certain symmetry properties, the incompressibility reduces to four the number of the independent components of the spectral tensor of the triple correlations at three points. The following two chapters are devoted to the establishment of the reduced equations of the spectral tensor of the correlations at two points on the basis of its known properties. The reduced equations of the spectral tensor of the correlations at three points are also established by using the results obtained in the second chapter. It is also shown that when the mean flow is a pure strain, the equations may be numerically integrated. Last chapter deals with the structure of mean values at the same point and especially that of the mean values of the product of two and three velocity derivatives and closes with considerations on the production and dissipation of the vortex.

Reviewer believes that the paper would have been more valuable if it had been completed by a numerical analysis of the phenomena. T. D. Oroveanu, Roumania

**348. Novikov, E. A., Concerning a turbulent diffusion in a stream with a transverse gradient of velocity,** *Appl. Math. Mech. (Prikl. Matb. Mekb.)* **22**, 3, 576–579, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Author discusses diffusion of an impurity from an instantaneous point source and does not extend solution to continuous or area sources. A constant settling speed of the

impurity and a linear variation of the horizontal wind with height are considered. By substitution of variables and a Laplace transform the diffusion equation is solved.

The solution for the most general case involves a matrix of time-dependent parameters of atmospheric turbulence about which nothing is known. By restricting the solution to a steady-state stream and choosing coordinate axes which correspond to the principal axes of the turbulent diffusion tensor, a manageable expression for the concentration is obtained. This differs from earlier solutions principally in that for long times the concentration decays as the minus 5/2 power rather than as the minus 3/2 power of time. It also shows that the wind shear tends to elongate the diffusing cloud. F. I. Badgley, USA

**349. Lyshevskii, A. S., Application of the turbulent diffusion laws for investigation of scattering of liquid streams out-flowing from small apertures** (in Russian), *Nauchn. Trudi Novocherkasskii Politekhn. In-ta* no. 39 (53), 49–66, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 830.

Equations of the turbulent diffusion of the liquid compound in the axisymmetrical air stream can be linearized by the partial exchange in the equations of mean-point-values of velocity, by the mean value throughout the cross section of the stream. The equations so obtained are analogous to the heat-convection equations and can be integrated by the conventional means. Theoretical results are compared with experimental data concerning the atomization of fuels. The theory agrees well with experiment in cross sections remote from the pipe outlet where the concentration of the liquid mixture is sufficiently small.

L. G. Loitsianskii

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**350. Kochetov, G. M., Losses in the grid of a turbine at the separation of flow** (in Russian), *Trudí Novocherkos. Politekhn. In-ta* no. 33/47, 97–101, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 410.

Results are presented of some experimental and theoretical investigations of the flow of the air beyond the nozzle grid. The grid is constructed with the ratio of the exit cross section to the critical equal to $q = 1.337$. The conditions at which a separation of flow from the blades occurs are found and its influence is established on the efficiency of grid. The maximum value for the efficiency obtained during the experiments was equal to $\varphi = 0.925$. A discrepancy in the optimum range between experimental and theoretical investigations can be explained, in the author's opinion, by the fact that in the calculations the effect of additional expansion of the stream was disregarded, which in effect reduces the width of the boundary edges of the outlet nozzles.

The results are produced of an experiment with a grid of active profiles with angles 20 and 25° and with a width of 32 mm; it was performed at $M = 1.02$. The existence of the secondary (backward) flow of gas was disclosed by means of oil and the optical method, which explains the reason for the separation of flow from the blades. M. F. Gubin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

## Aerodynamics

(See also Revs. 40, 308, 311, 312, 314, 319, 320, 375, 387, 403, 421, 468)

**Book—351. Schlichting, H., and Truckenbrodt, E., Aerodynamics of the airplane, Part I: Fundamentals of fluid mechanics, aerodynamics of the wing [Aerodynamik des Flugzeuges. Teil I. Grundlagen aus der Stromungsmechanik, Aerodynamik des Tragflugels],** Berlin, Springer-Verlag, 1959, xv + 455 pp. DM 52.50.

This is the first volume of a two-part work on the aerodynamics of the airplane in which the authors plan to treat the theory of the forces to which an aircraft is subjected in flight through the earth's atmosphere. The total work is to be divided into three main sections: fluid dynamic fundamentals, wing theory, and aerodynamics of the aircraft other than the wing. After an introductory section on the characteristics of the atmosphere this first volume treats the fluid dynamic theory and a portion of the wing aerodynamics section in five large chapters as follows: incompressible frictionless flow (hydrodynamics), compressible frictionless flow (gas dynamics), flows with friction (boundary-layer theory), introduction to wing theory, and the infinite wing incompressible flow.

The book is directed to engineers and contains those portions of flow theory which in the authors' view are indispensable to the aircraft designer. Emphasis is placed on clarity of presentation, succinctness of derivation and a choice of basic theory directed toward applications. Experimental results are introduced only to the extent of illustrating and supporting the theory. Each section is supported by a well-chosen selection of literature references.

The style of sections on flow theory is reminiscent of Prandtl's "Strömunglehre," while the boundary-layer portion borrows heavily from the first author's well-known text on this subject. It would be possible to cavil at minor points of this presentation, but in total it represents a treatment based on years of teaching experience which is admirably suited to an introduction to fluid mechanics for engineers.

The book contains an excellent selection of figures and plates and is published with the standards of excellence typical of books from the firm of J. Springer. L. M. Grossman, USA

**352. McCormick, B. W., The limiting circulatory lift of a wing of finite aspect ratio,** *J. Aero/Space Sci.* **26,** 4, 247–248 (Readers' Forum), Apr. 1959.

Experimental evidence indicates that the circulatory lift of a jet-flapped wing of finite aspect approaches a maximum as the momentum coefficient of the jet is increased. It has been suggested that this phenomenon is the result of strong tip vortices. A previously published experimental curve shows that the maximum circulatory lift of a finite jet-flapped wing varies nearly linearly with the aspect ratio. The analytical study presented here confirms these experimental results. It is shown that the maximum lift of a finite wing due to circulation, produced by any means whatever (suction BLC, blowing BLC jet-flaps, ordinary flaps) increases linearly with increasing aspect ratio. This behavior is attributed to the severe vertical displacement of the trailing vortex sheet at the high lift coefficients. This vertically displaced vortex sheet not only decreases the angle of attack of each wing element, as calculated in the usual lifting surface theories, but also subtracts from the incoming free-stream velocity, which effect is usually ignored in finite wing calculations. For ease of calculation only the case of the elliptic wing is treated, which is sufficient for demonstration purposes.

From author's summary

**353. Weber, J., The shape of the center part of a sweptback wing with a required load distrubution,** Aero. Res. Counc. Lond. Rep. Mem. 3098, 34 pp., 1959.

A method is given for determining the camber, twist and section shape of the center portion of a sweptback wing with constant spanwise and prescribed chordwise load distributions. Due to a singularity in the downwash at the center line of the wing, the usual linear theory is not directly applicable; an approximation is thus introduced involving the determination of the downwash at points displaced from the usual doublet sheet by half the local

wing thickness. Formulas for the downwash are deduced in supersonic, sonic and incompressible flows under linear chordwise variations in load distribution. The effects of variations in the free-stream Mach number, load distrubution, wing thickness and angle of sweep are determined and exhibited graphically.

E. E. Jones, England

**354. Hirsch, R., Theoretical study of the establishment of circulation around a profile having a jet at its trailing edge** (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 486–496.

The circulation and lift about a jet-flapped profile are determined uniquely by a trailing edge condition similar to that of Joukowsky in classical airfoil theory. The formation of the trailing edge vortex sheet caused by the jet is related to a condition similar to that used by Wagner in unsteady airfoil theory. This idea was also used by the reviewer in *Aero. Res. Counc. Lond., Curr. Pap* 388, 1953.

The law of decay of the vortex sheet downstream of the profile is shown to play an important role.

The relation of this work to that of the many other contributors is not indicated; no references are given.

L. C. Woods, Australia

**355. Whitcomb, R. T., and Heath, A. R., Jr., Several methods for reducing the drag of transport configurations at high subsonic speeds,** *NASA Memo* 2-25-59L, 12 pp., Mar. 1959.

Results of investigations of several promising methods for alleviating the drag rise of transport configurations at high subsonic speeds are reviewed briefly. The methods include a wing leading-edge extension, a fuselage addition, and additions on the wing. Also, results are presented for a complete, improved transport configuration which incorporates the fuselage and wing additions and shows that the improved configuration could have considerably higher cruise speeds than do current designs.

From authors' summary

**356. Stetter, H. J., Auxiliary tables for the computation of linearized wing-body interference flows,** AFOSR TN 58-1089 (Mathematik Technische Hochschule, München, TN 6; ASTIA 207 586), 33 pp., Nov. 1958.

An analysis of the Fourier decomposition used in the third step of the quasi-cylindrical method for the treatment of the linear wing-body interference problem shows that in a certain region the convergence of the resulting Fourier series is necessarily poor. It is shown how the solution may be composed of two parts such that the poorly convergent part is universal to all problems of this kind whereas the part distinguishing the various examples is better convergent.

Tables are presented of the universal portion of the solution of the third step giving the values of the flow component accounting for the local pressure coefficient in a large number of points on both wing and body. Instruction is provided on the use of these tables which reduce the necessary computations to those of the well-convergent second portion of the solution.

From author's summary

**357. Foley, W. M., and Reid, E. G., Jet flap thrust recovery,** *J. Aero/Space Sci.* **26,** 6, 385-387 (Readers' Forum), June 1959.

The purpose of the experiments described was to confirm or disprove the widely disputed theoretical prediction that the oblique discharge of air from such a wing should result in an upstream thrust of magnitude equal to that of the total jet momentum reaction, rather than that of its streamwise component. Toward that end, parallel vertical walls were installed in the open throat of the 7.5-ft diameter Stanford wind tunnel to enable determination of the air forces experienced in two-dimensional flow by a jet flap wing model of 12-in. chord and 24-in. span.

From authors' summary

**358. Funk, J., and Cooney, T. V., Some effects of yaw damping on airplane motions and vertical-tail loads in turbulent air,** *NASA Memo* 2-17-59L, 8 pp., Mar. 1959.

Results of analytical and flight studies are presented to indicate the effect of yaw damping on the airplane motions and vertical tail loads in rough air. The analytical studies indicate a rapid reduction in the airplane motions and the loads on the vertical tail as the damping is increased up to the point of damping the lateral motions of 1/2 amplitude in one cycle. Flight measurements indicate that a yaw damper reduces the loads on the vertical tail due to turbulent air and that the pilot could provide a significant amount of lateral damping.

From authors' summary

**359. Neumark, S., Collingbourne, J., and Thomas, H. H. B. M., A case of longitudinal stick-free dynamic instability of an aircraft fitted with power-operated control, g-restrictor and spring feel,** Aero. Res. Counc. Lond. Rep. Mem. 3094, 43 pp., 1958.

In aircraft with powered controls, the use of a spring and weight to provide "feel" for the pilot has, in at least one instance, led to instability which increased as aircraft speed increased. The authors' investigation shows that, even though the independent systems of aircraft, spring and weight, and power unit may individually be well damped, the damping may become inadequate when they are coupled together.

The stability characteristics resulting from the equations of motion of the coupled system were investigated by numerical calculation, by the use of an analog computor, and by the examination of Nyquist diagrams for the system.

Authors' leading conclusions are that (1) the use of weights in the circuits of power-operated controls may lead to dangerous instability; and (2) the transfer functions of power units for such service should be examined in relation to the aircraft dynamics. The dangerous effect of the weight may be reduced when the weight is placed close to the aircraft c. g. but this cannot be counted on without detailed examination in each case.

M. A. Mayers, USA

**360. Booth, Katherine W., Effect of horizontal-tail chord on the calculated subsonic span loads and stability derivatives of isolated unswept tail assemblies in sideslip and steady roll,** *NASA Memo* 4-1-59L, 32 pp., Mar. 1959.

Geometric variables covered in this investigation included horizontal-tail chord, horizontal-tail span, vertical location of the horizontal tail, and horizontal-tail dihedral angle. The vertical and horizontal surfaces had unswept quarter-chord lines and taper ratios of 0.5. Calculations were restricted to configurations having a vertical tail of aspect ratio 1.0.

From author's summary

## Vibration and Wave Motion in Fluids

(See also Revs. 29, 468, 493, 495, 524, 534)

**361. Sideriades, L., The stability of two parallel connected surge tanks without throttling losses** (in French), *Houille Blanche* **13,** 4, 442-449, Aug.-Sept. 1958.

Author considers a hydroelectric power plant supplied by two independent pressure tunnels which connect to a single penstock downstream of two surge tanks. The conditions for surge stability in this complex hydraulic system are analyzed. The system of dif-

ferential equations is developed neglecting the throttling losses. The analysis of this nonlinear system leads to a characteristic equation of the fourth degree, the roots of which are analyzed (condition of Routh-Hurwitz). Discussion is summarized in diagrams defining, for different practical situations, a region of the plane of the inverse cross section of the surge tanks where the system is stable. The aggregate cross section of the two surge tanks necessary for stability is remarkably smaller than that of a system with a single tank (Thoma's section). G. Noseda, Italy

**362. Oser, H., Experimental investigation of harmonic oscillation in rotating fluids** (in German), *ZAMM* **38**, 9/10, 386–391, Sept./Oct. 1958.

Paper describes an experimental investigation of the theoretically predicted existence of characteristic lines in a uniformly rotating inviscid incompressible fluid. A harmonically oscillating circular disk originates pressure disturbances at the disk's edge, which are propagated along the characteristic lines. The characteristic lines are made visible by differences in the concentration of aluminum particles in the fluid (water).

The investigation does show the existence of characreristic lines for disturbance frequencies smaller than twice the rotational frequency. The experimental results for the characteristic angles are in close agreement with theory. H. Bergh, Holland

**363. Bagdoev, A G., The penetration of pressure into the depth of a compressible liquid** (in Russian), *Vestn. Mosk. In-ta, Ser. Matem., Mekhan., Astron., Fiz., Khimii* no. 2, 19–26, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5114.

The problem is investigated of the penetration into the depth of a compressible liquid of a pressure having its origin at some point on the surface and then spreading and distributing in accordance with an arbitrary but known principle. Cases are examined where the velocity of pressure spreading on the surface is larger, smaller or equal to the velocity of sound in a liquid of infinite depth. The agitated motion of the liquid is taken to be potential. The problem, stated in linear terms, merges with the solution of the wave equation of a motion with axial symmetry. In the case of a liquid of unlimited depth the problem was solved by the method of sources. In the case of a liquid of finite depth the solution was made by Fourier's method. In both cases expressions were obtained for the pressure at any arbitrary point in the liquid.

P. P. Koryavov
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**364. Labzovskii, N. A., Calculations of the elements of waves in shoal water** (in Russian), Problems of river run-off control, no. 6, Moscow, Akad. Nauk SSSR, 1956, 278–296; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4156.

Empirical formulas are proposed for the calculations for wave elements in shoal water by using the known values in deep water. The length of a wave in shallow water is obtained by using the author's formula: multiplying the length of the deep water wave by the empirical coefficient, depending on the relation of the local depth of water of the spot to the length of the deep water wave. The height of the wave is found in analogous fashion, with the difference that the multiplier used for the transition from the height of the deep water wave to the height of the shallow water wave depends, in addition, on the relation of the depth to the length of the shallow water wave. In addition, a table and a nomogram of the author's is furnished for ascertaining the deep-sea-wave elements in relation to the wind velocity and the length of the race (interwave). Comparisons are given of the heights of waves calculated by the proposed formulas with the data of actual observations on the heights of waves in deep water and shallow water of lakes. No account is taken in the formulas on the probability of the calculated elements. Together with this consideration, in the view of the author, the probable characteristics of the wave elements should be determined in relation to the interval of time during which the process in investigated. Apart from the examination of the characteristics of wave action, extending over small intervals of time, emphasis is laid on the importance of investigations of statistical characteristics embracing many years.

Yu. M. Krylov
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**365. Schlag, A., and Lebecque R., A new method for the calculation of water power** (in French), *Bull. Centre Études Genie Civ.* **9**, 293–318, 1957.

Paper deals with a graphical solution of partial differential equations of the second order, the example being the basic equation on water-hammer problems. The solutions of the basic equation by Allieve and the graphical treatment by Schnyder-Bergeron are supposed to be known. Some simple remarks on the tracing of "wave lines" and the different ways of "reading" such diagrams are the starting point of a simplified graphical method. Writer believes that a similar re-arrangement of the basic wave equations could also be useful for simplifying calculations on the digital computer. C. Jaeger, England

## Fluid Machinery

(See also Revs. 317, 421, 443, 444)

**366. Preger, E. A., The parallel work of pumps** (in Russian), *Nauchn. Trudi Leningrad Inzh.-stroit. In-ta* no. 25, 51–58, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5357.

The fact is noted that when pumping stations with parallel working pumps are designed, the required pump pressure is always determined for the case of their mutual work in delivery into the network of the calculated discharge of water. Consequently the output of the pumps erected should be taken at their rated output value without applying correction coefficients lowering the output, as is frequently but erroneously done. When including separate pumps from the number established or when adding supplementary pumps the output of the parallel-acting pumps is changed. To determine the output of the pumps in such a case an analytical method is proposed; this is based on the circumstance that the required pressure, determined by the characteristic of the net $H_c = c_0 + c_2 Q_c^2$, equalizes out with the pressure of the compression station

$$H = a_0 + \frac{a_1}{n} Q_n + \frac{a_2}{n^2} Q_n^2,$$

where $n$ is the number of parallel working pumps, $Q_n$ the total output of the parallel working pumps, $c_0$, $c_2$, $a_0$, $a_1$, $a_2$ known coefficients. The value $Q_n$ in relation to the number of pumps $n$ is determined by the formula

$$Q_n = \frac{-\frac{a_1}{n} \pm \sqrt{\left(\frac{a_1}{n}\right)^2 - 4\left(\frac{a^2}{n^2} - c_2\right)(a_0 - c_0)}}{2\left(\frac{a_2}{n^2} - c_2\right)}$$

V. Kh. Abiants
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**367. Sen, A. K., Screw pump and its application** (in English), *J. Sci. Engng. Res., India* **1**, 1, 103–112, Jan. 1957.

The screw pump which has been utilized as a lubricator is experimentally tested. By making pumps of various designs and running them with different lubricating oils it is concluded that pumps of shallow groove and wide angle can work satisfactorily in lubricating systems. It is also suggested that the screw pump with no discharge can be utilized as a pressure-pump. The advantages and difficulties are discussed. From author's summary

**368. Tyutin, I. A., An introduction to the theory of induction pumps** (in Russian), *Trudi In-ta Fiz. Akad. Nauk LatvSSR* **8**, 49–58, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5519.

The theoretical principles of induction pumps are investigated. General equations are brought in for the flow of the conducting liquid in the electromagnetic field which, after introducing the vector-potential function $B = \text{rot } A$, take the form

$$\text{rot rot } A + \mu\gamma \left\{\frac{\partial A}{\partial t} - [u \times \text{rot } A]\right\} = 0$$

$$\frac{\partial u}{\partial t} + (u\nabla)u = \frac{\gamma}{\rho}\left[\left\{[u \times \text{rot } A] - \frac{\partial A}{\partial t}\right\} \times \text{rot } A\right] - \frac{1}{\rho}\nabla p + \nu\nabla^2 u$$

Inductance pumps should be constructed in such a way that the force, appearing as the result of the interaction of the running electromagnetic field and the current induced in the liquid metal, should coincide in direction with the velocity vector of the flow of the liquid and should be oriented along the neck of the pump. Divergence from this requirement should have no appreciable significance. In conformity with this requirement the initial equations become somewhat simplified. Assuming the character of the flow to be laminar, author examines the case more frequently met with in practice, where the clearance between the inductors is so much smaller than the depth of penetration of the running electromagnetic wave in the liquid metal that the expression $\partial A/\partial x \approx 0$ can be accepted. Assuming that the vector-potential of the harmonic function

$$A = A_m e^{i(\omega_1 t - \alpha x)} \qquad \left(\alpha = \frac{\pi}{t}\right)$$

(where $t$ is the polar step) and averaging by means of the time and space coordinates the magnitude of the mass forces and pressure, author finds the distribution of the velocity of flow of the liquid metal in the neck (the transverse section of which has the shape of a narrow slit) and determines the mean velocity by the section of the neck, the working pressure developed by the pump, and the magneto-hydraulic losses of pressure in the neck. A reference is made to the effective value of the kinematic coefficient of viscosity $\nu_1$ and the magnetohydrodynamic criteria of Reynold's $R$.

V. A. Bashkin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**369. Martin, Moira E., A note on the control of secondary flow by using cascades of twisted blades,** Aero. Res. Counc., Lond., Curr. Pap. 425, 11 pp., 1959.

The object of secondary flow control is to reduce one (or more) of the adverse effects which that flow introduces. The suggestion here is that by varying the blade camber in accordance with the inlet velocity distribution correction can be made for the phenomenon of overturning near the walls. It is hoped that the reduction of camber at the blade tips which this necessitates will also favorably affect the position of the separation point on the blade surfaces in the corners. Preliminary experiments demonstrating these improvements are reported here: they are of a restricted nature owing to the fact that they were designed primarily to test a first-order secondary flow theory for twisted blades. Nevertheless, the results are encouraging and it is hoped that they may lead eventually to a method of improved blade design.

From author's summary

**370. Horlock, J. H., and Deverson, E. C., An experiment to determine the position of an equivalent actuator disc replacing a blade row of a turbomachine,** Aero. Res. Counc. Lond. Curr. Pap. 426, 6 pp., 1959.

One difficulty encountered in the application of actuator disk theory to analyze turbomachine performance is that the axial location of the equivalent disk replacing the blade row has not been satisfactorily determined, analytically or experimentally. This paper describes an experiment in which axial velocity profiles have been measured at many axial locations upstream and downstream of a moving row. Changes in axial velocity outside the row are compared with the exponential decay of axial velocity perturbations predicted by simple actuator disk theory. It is found that the simple theory gives adequate prediction of the observed axial velocities if the disk is located near the axial center line of the blades. From authors' summary

**371. Reiner, M., The centripetal-pump effect in a vacuum pump,** *Proc. Roy. Soc. Lond.* (*A*) **247**, 1249, 152–167, Sept. 1958.

An instrument is described which works as a centripetal vacuum pump. It consists of two circular metal plates, one stationary, the other rotating opposite it. The stator has an opening in the center. The rotor can be freely displaced along the axis of rotation. By centripetal pumping action it is kept floating on an air cushion of thickness $D$. The relation between $D$ and the speed of rotation was determined for different weights of the rotor to be supported. The results are interpreted on the basis of Maxwell's theory of the elastico-viscosity of air. From author's summary

**372. Dorfman, L. A., Calculations for the flow past a rotating blade assembly** (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 12, 121–125, 1956; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6541.

A method is demonstrated for the calculations of the flow past a rotating blade assembly. The method is based on the preliminary transformation from a blade assembly in the plane of a complex variable $z$ to a straight assembly in the plane $z_1$ by using the formula

$$z_1 = \frac{n}{2}\log_e \frac{z}{\sqrt{R_1 R_2}}$$

($n$ is the number of blades in the assembly, $R_1$ and $R_2$ are the radii of the rings touching the edges of the blades). Plane $z_1$ is then transformed to a flat plate assembly with no change of origin. For this purpose use is made of an integral correlation proposed previously by the author [*Prikl. Mat. Mekh.* **16**, no. 5, 1952: "Method applicable to the calculations for blade assemblies of high solidity"]. Examples of the calculations are given.

M. I. Zhukovskii

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**373. Bosek, B., Selection of the optimum distribution of pressures among stages of the multi-stage compressor** (in Czech), *Aplikace Mat.* **2**, 1, 47–57, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 453.

The most profitable distribution of pressures is suggested among stages of the multistage compressor. The problem is solved by finding the extreme of the function $k - 1$ of the independent variables which describe the function of the $k$-stage compressor.

V. Kh. Abiants

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**374. Tselikov, V. A., Scaling of turbine regimes with a heavy gas** (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 10, 19–27, Oct. 1957.

This paper examines methods to study regimes of turbines and turbomachines in general by using working fluid with small gas constant $R$ at medium temperatures. This reduces the speed and power of the turbine and compressor, the experimental set up is simplified and the necessity for dimensional scaling is removed. The experimental turbine buckets can be made of easily machined materials or even cast.

From author's summary by A. Petroff, USA

**375. Iwasaki, M., Diagrams for use in calculation of induced velocity by propellers,** *Rep. Res. Inst. Appl. Mech. Kyushu Univ.* **6,** 23, 87–126, 1958.

Author studies velocity induced by vortex system of propellers having an infinitely large number of blades. Results are similar to those for vortex ring but are more general due to inclusion of tangential component of velocity. Tables and diagrams are useful.

R. A. A. Bryant, Australia

## Flow and Flight Test Techniques and Measurements

(See also Revs. 28, 313, 362, 468, 526)

**376. Maslach, G. J., Some problems associated with the measurement of very low pressures,** AGARD Rep. 175, 30 pp., Mar. 1958.

The measurement of very low pressures in aerodynamic investigations requires unique instrumentation and attention to certain factors not normally considered in the measurement of higher pressures. The several types of pressure-sensitive elements now used are described with a brief indication of their special values or defects. A method of design for the connecting line joining an orifice to a pressure-sensitive element is presented. The time response of the measurement system determined by this method is shown to be influenced by outgassing effects within the volume of the system and variable temperatures acting along the connecting line. Measurement of and correction for these effects are indicated. Measurements made with certain geometries of impact and conical pressure probes are presented to illustrate the type and magnitude of the external flow effects associated with flows at low densities.

From author's summary

**377. Redding, T. H., Definition and significance of the flow coefficient in accelerated flow, with special reference to metering devices** *J. Electronics and Control,* Oct. 1957, 30 pp.

**378. Sackmann, L.-A., and Wagner, M. A., Determination of viscosity by energy dissipation** (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 458–474.

Authors discuss a technique for measuring viscosity in a device similar to that used by Joule for the mechanical equivalent of heat. In this application, the viscosity is found by measuring the rate of energy dissipation between concentric rotating cylinders. Experimental results indicate about 5% absolute accuracy and 0.5% relative accuracy.

W. C. Griffith, USA

**379. Ivanov, P. A., Measurement of viscosity** (in Russian), *Zavod. Lab.* **23,** 4, 457–460, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6921.

A description is furnished of a rotating electro-viscosimeter; the inside cylinder of the apparatus is revolved by means of a synchronous micro-electric motor. The speed of rotation of the inside cylinder remains constant during measurement of the viscosity and can be altered by means of a frequency transformer. The moment of friction, applied to the inside cylinder of the viscosimeter, produces shear of the vector of the electromotive force of the stator in relation to the vector of the applied stress at some angle. The viscosity of the liquid is determined by the size of this angle. The angle of shear of the vector of stress in relation to the vector of electromotive force of the stator is not great (up to 8°), and, because of this, a linear dependence is obtained between the moment of friction in the layer of liquid and the difference between the two vector angles.

A. I. Golubev

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**380. Tanner, L. H., The optics of the Mach-Zehnder interferometer,** Aero. Res. Counc. Lond. Rep. Mem. 3069, 62 pp., 1959.

The paper is intended to give a complete optical theory of the Mach-Zehnder interferometer, without using difficult mathematical methods or complicated three-dimensional diagrams.

The topics covered include the effect of the spectral distribution of the source, with and without dispersion. The effect on the fringe contrast of the size and shape of the source are considered. These effects are related to the fringe pattern which is produced near the usual source position if a source is placed in what is normally the emergent beam. This fringe pattern is related to the displacement of the two images of a co-ordinate system in the emergent beam, as seen through the four-mirror system. The effects of all such displacements are discussed and illustrated. The effect of mirror movements on these displacements is analyzed, to show the number of fine adjustments required, and the effect of each.

A section on the imperfections of the optical elements includes discussions of the effects of differences of thickness, incidence and refractive index, wedge angles, surface flatness and refractive index variation. Except for the permissible wedge angles, the limits found necessary are less strict than those usually given. Aberration of the collimating lens has practically no effect.

A review of methods of adjustment of the interferometer includes descriptions of some of the well-known methods and of two which do not appear to have been described previously. Of these, one is a method for obtaining a parallelogram arrangement, which was used by K. J. Habell, and the other is an accurate method for final adjustment based on the source-plane fringe pattern.

From author's summary

**381. Batailler, G., and Chartier, Ch., Chronophotography of nonstationary fields of flow** (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 421–429.

Electronic circuits, light sources and mechanical techniques are described for obtaining flash photographs of two-dimensional nonstationary flows. Stream direction and quantitative measure of velocity are obtained by multiple-flash pictures of visible particles carried by the fluid. Typical examples of applications include starting vortices generated by a flat plate moving normal to itself and the vortex generated behind a wall.

W. C. Griffith, USA

**382. Bouyer, R., and Chartier, Ch., Densitometer study of photographs of gas flows obtained by phase contrast** (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 430–437.

Authors discuss the problem of quantitative interpretation of phase contrast photographs of compressible fluid flows. A general description of equipment used and results obtained for the case of a jet are included.

W. C. Griffith, USA

**383. Gontier, G., Remarks on the operation and calibration of birefringent devices for interferometric application to aerodynamics** (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 447–457.

Paper describes an experimental technique for determining velocity fields in compressible flow. The optical system uses a Wollaston bi-prism which gives a fringe pattern whose properties

may be related quantitatively to a two-dimensional flow field. A suitable analysis is presented. W. C. Griffith, USA

**384. Spence, D. A., and Bennett, A. S., Model tests on an effuser induction scheme for operating a transonic wind tunnel,** Aero. Res. Counc. Lond. Curr. Pap. 420, 29 pp., 1959.

Model tests in a 1/6th scale rig on a proposed design for the 2 ft × 1½ ft "By-Pass" transonic wind tunnel are reported. To take advantage of the pressure ratio of 2.0 available at full scale, a two-dimensional supersonic nozzle, or "effuser," has been designed to expand the main stream from the working section up to a Mach number just above 2 at the point where it is vented to the plenum chamber, to induce re-entrant flow. The expansion is considerably larger than has been used in other known diffuser-suction wind tunnels, and appears to be capable of generating Mach numbers approaching 1.4 in the working section. The tunnel design may also be novel in that the model-support rig is to be situated upstream of the re-entry point.

The suction flow from the working section, and hence the tunnel Mach number, is to be regulated by re-entry doors. Characteristic curves of Mach number against door opening and overall pressure ratio were obtained. In addition the inflow through the doors was examined by schlieren methods, using perspex-sided models, and extensive pressure plotting was carried out on the four effuser designs tested. From authors' summary

**385. Hall, C. N., A simple method of improving the supersonic velocity distribution in a transonic tunnel having slotted walls,** Aero. Res. Counc., Lond., Curr. Pap. 421, 13 pp., 1959.

This note describes how the center line distribution of Mach number in the R.A.E. 8-ft × 6-ft transonic tunnel has been modified at supersonic speeds by means of curved lengths of perforated steel plate set behind a proportion of the suction slots in the walls of the working section. It was found that the slope and curvature of the perforated strips and the distance from the suction slots determined their effect on the distribution of Mach number. A form of plate was evolved which reduced the variation of Mach number about the mean from ±0.010 to ±0.006 at the maximum Mach number. From author's summary

**386. Anderson, G. F., Shock-tube testing time,** *J. Aero/Space Sci.* **26,** 3, 184–185 (Readers' Forum), Mar. 1959.

As the slug of test gas between the shock front and interface advances, some of the gas "leaks" into boundary layer and is lost. Lost test gas decreases test time $\tau$. An analysis neglecting boundary layer indicates that $\tau$ increases indefinitely with tube length. Allowance for the boundary layer shows that there is a tube length giving maximum $\tau$; longer tubes decrease $\tau$. A formula is derived using the continuity equation and gives the ratio of $\tau$ allowing for a turbulent boundary layer to $\tau$ neglecting boundary layer as a function of initial pressure, tube diameter, shock Mach number and distance measured from diaphragm. Numerical integration is required to apply the formula. A specific case is given for initial pressure of 10 cm Hg and tube diameters of 1½ and 4 inches. In a 4-in. tube maximum $\tau$ occurs near 50-ft station; in 1½-in. tube, near 15-ft station. An attenuated wave gives only about ½ ideal test time. A. Fuhs, USA

**387. Port, W. G. A., and Morrall, J. C., Flight tests of a simple method of measuring pressure distributions on a wing,** Aero. Res. Counc., Lond., Curr. Pap. 422, 20 pp., 1959.

Small-bore plastic tubes, stuck to the wing surface and drilled for pressure measurements at selected points, are shown to be a reasonably suitable basis for the measurement of pressure distributions in flight. Only a small fairing on each side of the tubes is required, but crossflow should be avoided as far as possible.

Results are presented for the pressure distributions around the wing center-section of a Meteor aircraft, both in free air and near the ground. From authors' summary

## Thermodynamics

(See also Revs. 28, 57, 379, 395, 399, 420, 432, 443, 456, 495)

**Book—388. Scott, R. B., Cryogenic engineering,** Princeton, N. J., Van Nostrand Co., Inc., 1959, xi + 368 pp. $5.60.

This lucid and well-written treatise will be of greatest value to engineers and scientists who are unfamiliar with cryogenic techniques, but it is also a valuable reference for the specialist. A working knowledge of physics, thermodynamics, and mathematics is of course assumed, but mathematical analysis is kept at a minimum. The treatment is, in general, practical rather than theoretical. Subjects covered include liquefaction and separation of gases; storage, transport, and transfer of liquefied gases; cooling by adiabatic demagnetization; low-temperature thermometry; and insulation. The last two chapters deal with properties of cryogenic fluids and low-temperature properties of structural materials, and are replete with useful tables and graphs. Much of the material is the result of recent experience at the National Bureau of Standards Cryogenic Engineering Laboratory, and, to the reviewer's knowledge, is not available elsewhere in book form. The usual number of typographical errors are present, but fortunately they are fairly obvious (e.g. in the equation on p. 102 exponents are dimensionally wrong).

In a rapidly growing field it is virtually impossible to include very recent developments, and the present volume is no exception. For example, continuous refrigeration, miniaturized refrigerators, and so-called "super-insulation" are not discussed. However, this is not a serious deficiency, and on the whole the book is both timely and authoritative. Reviewer believes it is an invaluable addition to the literature of cryogenics, and can be recommended to every worker in that field. C. Chase, USA

**Book—389. Temperley, H. N. V., Changes of state—a mathematical-physical assessment,** New York, Interscience Publishers, Inc., 1956, xi + 324 pp. $7.50.

This book is devoted to a review of the problems and phenomena of phase transitions. Following a brief historical introduction, changes of state are classified and general theoretical considerations given. This occupies the first 51 pages of the book. Then, in order, the following topics are discussed: Evaporation and liquefaction (45 pp.), fusion and solidification (17 pp.), solutions, adsorption, etc. (58 pp.), ferromagnetism and antiferromagnetism (55 pp.), ferroelectricity and point anomalies in solids (20 pp.), superconductivity (31 pp.), and, finally, liquid helium (44 pp.).

The approach throughout the book is one of a physicist, and considerable effort has been expended to ensure that the discussion clearly indicates the physical principles rather than a detailed mathematical approach. In general, the book provides a stimulating discussion of problems of the physics of phase transitions and phenomena. The reviewer found the sections dealing with evaporation, ferromagnetism, superconductivity and liquid helium to be particularly interesting. The physics of ionized and dissociated gases is not discussed. In view of the great interest presently centering on plasmas which act quite differently from low temperature gases and can thus be regarded as a distinct phase, author might well consider such a section to be useful addition in future editions.

As was clearly indicated in the preface, only a selection of reference material is given. These could be extended somewhat and summary tables given so that the interested reader could readily

find further references on a particular aspect of a given topic. No attempt is made to introduce empirical correlations, generalized relations, etc., and thus some excellent methods of approaching some of the problems are not utilized. For this reason the engineer will find little information of directly usable form in the book; it is of greater use to the physicist interested in reviewing studies in this subject or to the engineer who is prepared to devote a sizable period of time to the understanding of the fundamentals of the phenomena.

Typographically the book is well produced. No general author index is provided, which detracts somewhat from its utility and it is to be hoped that one will be provided in any future editions.

P. E. Liley, USA

**390. Swift, G. W., Christy, J. A., and Kurata, F., Liquid viscosities of methane and propane,** *AIChE J.* **5,** 1, 98–102, Mar. 1959.

There are very few data on viscosities of normally gaseous hydrocarbons in the liquid phase above their normal boiling points.

The data presented range from the normal boiling point to the critical point of the hydrocarbon tested. In addition, the data are consolidated with those of the American Petroleum Institute, which are given from the freezing point to the normal boiling point. The end result is a consistent set of viscosity data for methane and propane which extend over their entire liquid range.

From authors' summary by L. Escande, France

**391. Paladino, A. E., Swarts, E. L., and Crandall, W. B., Unsteady-state method of measuring thermal diffusivity and Biot's modulus for alumina between 1500° and 1800° C.,** *J. Amer. Ceram. Soc.* **40,** 10, 340–345, Oct. 1957.

**392. Horlock, J. H., Approximate equations for the properties of superheated steam,** Instn. Mech. Engrs., Prepr., 11 pp., 1958.

Equations have been developed for $C_p$, the specific heat at constant pressure, and $Ra = pv/T$ as functions of entropy for only superheated steam. These have been used to obtain an equation of state. From these it also follows that steam should behave as a perfect gas in isentropic processes, and values of ent ny, etc., may be calculated.

The relations are found to give good results in the range of 200 to 2000 lb/in.$^2$ and 400 to 1000 F. They supplement the results of Callendar and others for lower pressures and temperatures. They may be useful in extending the range for calculations for preliminary design studies over most of the practical subcritical range for steam properties. R. C. Anderson, USA

**393. Sundheim, B. R., Transport processes in multicomponent liquids,** *J. Chem. Phys.* **27,** 3, 791–795, Sept. 1957.

**394. Li, J. C. M., and Ting, T. W., Thermodynamics for elastic solids in the electrostatic field. I. General formulation,** *J. Chem. Phys.* **27,** 3, 693–700, Sept. 1957.

**395. Heller, L., Equilibrium statistical mechanics of dissociating diatomic gases,** *Physics of Fluids* **2,** 2, 147–152, Mar. Apr. 1959.

For diatomic molecule AB in equilibrium with dissociated atoms in stoichiometric concentration, author derives approximate expressions for pressure, density, entropy and enthalpy as functions of temperature and fractional dissociation, assuming complete rotational and zero electronic excitation. Results are expressed graphically in reduced coordinates. Author also discusses approximation and errors in neglecting vibration.

I. M. Krieger, USA

**396. Denbigh, K. G., Nonequilibrium thermodynamics: a survey** *AIChE J.* **5,** 1, 20–25, Mar. 1959.

Paper is an authoritative review of the thermodynamics of irreversible processes. The essential steps in the application of this new branch of thermodynamics are the formulation of the entropy production, from which the conjugate fluxes and forces can be selected, the setting up of a system of linear equations and finally, the application of Onsager's reciprocal relations to the coupling coefficients. Author correctly indicates the scope and limit of this method and warns against overexaggeration of its usefulness.

L. S. Dzung, Switzerland

**397. Pattison, F. R., Ingot surface-temperature measurement in forging furnaces,** *J. Iron Steel Inst.* **191,** 2, 163–170, Feb. 1959.

**398. Styrikovich, M. A., Investigations of a salt carried away by vapor and of the hydraulics of two-phase liquids by radioactive-isotope method** (in Russian), Session of the Akad. Nauk SSSR on the peaceful use of atomic energy, 1955, Moscow, Izd-vo Akad. Nauk SSSR, 1955, 210–227; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 879.

The aim of the investigations of salts carried away was to relate the content of impurities in steam with the pressure, temperature, especially loading and concentration of salts in the water which are characteristic of up-to-date steam-turbine units. The common concentration of impurities in a steam is less than 0.2 mg per kg of steam. By means of the radioactive salts it is possible to detect separate ingredients in amounts up to $10^{-5}$ mg/kg. Amount of the impurities in a steam is determined by measuring a radioactivity of the condensed water.

Salts and other water-soluble ingredients are carried away by the vapor partly because they appear in the water droplets and partly because salts are soluble in the vapor. A transfer by liquid droplets is characterized by the loss coefficient which depends upon steam velocity, pressure and the liquid level. A salt transfer by a dry steam is characterized by the so-called coefficient of dispersion. It was found that the coefficient of dispersion is proportional to some power ratio of the specific weights of the steam and liquid. The power exponent is constant for any particular solution.

An effect of "swelling" of the water volume was observed which was due to a formation of bubbles inside the liquid as a result of irradiation by a narrow $\gamma$-ray beam. The influence of the salt concentration was investigated on the water volume change and on the loss coefficient. The irradiation by $\gamma$-ray was applied also to investigate the structure of steam-water mixture and the steam and water distribution in the cross section of a pipe in flows through horizontal and slightly inclined pipes. D. A. Efros

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*Translation, courtesy Ministry of Supply, England*

## Heat and Mass Transfer

(See also Revs. 6, 26, 297, 301, 307, 326, 328, 329, 348, 349, 397, 428, 435, 439, 454, 466, 532, 533)

**Book—399. Physics and heat technology of reactors** (translated from the Russian), New York, Consultants Bureau, 1958, v + 174 pp. $22.50.

Contrary to the impression conveyed by the title, but as pointed out in the editor's note, this is not a book in the usual sense of continuity of its parts. It is, rather, a selection of eighteen technical papers on important but highly speciallized and almost unrelated topics. The first twelve papers would be of interest primarily to physicists concerned with neutron diffusion, criticality, fission-product yields, $Xe^{135}$ cross-section, $\gamma$-scattering, and low-delay thermopiles. The last six papers pertain to engineering problems such as fuel element shapes, optimization of thermodynamic cycles, radioactive deposits in steam lines, and

other thermal cycle considerations related to nuclear power. The high cost of this collection of papers probably reflects the expectation of few individual purchases. No technical library, however, should be without this volume. It is the reviewer's hope that additional English translations of similar nature will appear from time to time as warranted by developing Russian technology.
J. A. Scanlan, USA

**400. Vodicka, V., Some problems on heat conduction in stratiform bodies,** *J. Phys. Soc. Japan* **14,** 2, 216–224, Feb. 1959.

Problems of heat conduction in multilayer bodies are treated by solving finite numbers of unidimensional unsteady heat conduction equations with matching boundary conditions. The Laplace transform is used to give a general form of the solution. It is then applied to some special cases of simpler nature.
L. N. Tao, USA

**401. McKenzie, K. I., A deuce programme for the solution of two-dimensional heat-flow problems,** Aero. Res. Counc. Lond. Curr. Pap. 417, 19 pp., 1959.

A program is devised to calculate by a finite difference method the transient temperature distributions in any cylindrical body, provided its cross section can be mapped on a square network in such a way that no line of the net crosses its boundary more than twice. The program requires the boundary conditions to be linear functions of temperature and heat flux, independent of time. The initial temperature distribution is arbitrary. The results of the program are compared with analytical solutions in two simple cases, and two further problems are solved. The program is stored in the R.A.E. Programme Library. From author's summary

**402. Thorne, C. J., Temperature tables, Part I. One-layer plate, one-space variable, linear,** China Lake, Calif., Research Dept., U. S. Naval Ordnance Test Station, NAVORD Report 5562, NOTS 1756, 711 pp., July 1957.

This report presents extensive tabulations representing numerical solutions of the transient heat conduction equation for an infinite plate with constant but independent values of the unit surface conductance on each side. The initial condition is that of a uniform temperature through the plate equal to that of the environmental temperature on one side. The change in temperature from the initial value is expressed as a fraction of the difference between the environmental temperature on either side. These values are tabulated as a function of position across the plate and also as a function of the dimensionless time parameter over the range

$$0.001 \leq \frac{kt}{c\rho L^2} \leq 1000$$

The surface conductance parameter is likewise assigned discrete values over the range

$$0.001 \leq \frac{hL}{k} \leq 1000$$

This parameter is varied independently on each side of the plate.
T. J. Connolly, USA

**403. Kemp, N. H., Rose, P. H., and Detra, R. W., Laminar heat transfer around blunt bodies in dissociated air,** *J. Aero/Space Sci.* **26,** 7, 421–430, July 1959.

A method of predicting laminar heat-transfer rates to blunt highly cooled bodies with constant wall temperature is developed, compared with previous work by Lees and with experimental data. Method uses similarity transformation and then patches similar solutions together to match local pressure field. Experimental data points scatter about calculated curves for hemispherical cap on cylinder and flat-nosed cylinder. M. Tribus, USA

**404. Keller, H. H., and Somers, E. V., Heat transfer from an annular fin of constant thickness,** *Trans. ASME* **81C,** (*J. Heat Transfer*), 2, 151–156, May 1959.

A mathematical analysis of the heat transfer from an annular fin of constant thickness. The two-dimensional solution is presented in graphical form, from which design information may be obtained for fins of small height-to-thickness ratio and large height-to-inner-radius ratio. Previous solutions are compared to the one presented in the paper, and certain limitations are pointed out.
G. A. Hawkins, USA

**405. Siegel, R., and Sparrow, E. M., Simultaneous development of velocity and temperature distributions in a flat duct with uniform wall heating,** *AIChE J.* **5,** 1, 73–75, Mar. 1959.

Approximate solution of temperature and Nusselt number distribution in a two-dimensional channel with uniform heat flux through the walls. The analysis is carried out for laminar motion from the entrance into the channel to fully developed flow conditions inside the channel and for Prandtl numbers smaller and larger than 1.0.
S. Eskinazi, USA

**406. Thomson, R. G., Effects of cross-sectional shape, solidity, and distribution of heat-transfer coefficient on the torsional stiffness of thin wings subjected to aerodynamic heating,** *NASA Memo* 1-30-59L, 31 pp., Feb. 1959.

Previous analysis has shown significant loss of torsional stiffness from aerodynamic heating in thin wings rapidly accelerated to supersonic speeds. Present report (also based on analysis, not on experiment) reaches conclusion that principal factor determining loss is distribution of heat-absorbing mass of airfoil cross section. Investigation included the following wing types: (1) solid double wedge; (2) hollow double wedge; (3) hollow double wedge with internal webs. Effects of flattening, blunting, and combination of these on (1) also investigated. Effect of heat-transfer coefficient is studied for: (1) constant value; (2) chordwise variation corresponding to type of flow (laminar, turbulent); (3) chordwise variation in arbitrary steps.

It is, of course, difficult to make such calculations which we can be sure are meaningful and generally applicable, even only qualitatively, but statements by author seem unnecessarily ambiguous. Thus, under *Summary*, we read: "The influence of chordwise variations in heat-transfer coefficient due to turbulent and laminar boundary-layer flow on the torsional stiffness of solid wings is negligible." Under *Concluding Remarks* we read: "The per cent reduction in torsional stiffness in a hollow double-wedge section, which is due entirely to the chordwise variation in heat-transfer coefficient caused by laminar and turbulent flow, is much smaller in magnitude than that calculated for a solid double wedge" (negligibility squared?). However, in view of almost complete lack of such information elsewhere, data given in this report should be a useful guide in estimating or allowing for stiffness reduction in practical problems. C. W. Smith, USA

**407. Scanlan, J. A., Effects of normal surface vibration on laminar forced convective heat transfer,** *Indust. Engng. Chem.* **50,** 10, 1565–1568, Oct. 1958.

Normal vibration of a heating surface can have a pronounced beneficial effect on heat transfer. The local heat-transfer coefficient can be predicted from an equation in the paper.
From author's summary

**408. Dunn, D. W., and Reid, W. H., Heat transfer in isotropic turbulence during the final period of decay,** *NACA TN* 4186, 68 pp., June 1958.

The problem of heat transfer in isotropic turbulence with a constant mean temperature gradient is considered during the final period of decay. The Reynolds and Péclet numbers are then very

small, and all triple correlation terms can be neglected in the equations for the double correlations. On this basis it is found that the temperature field ultimately becomes independent of the initial conditions on the temperature and has characteristics determined only by the mean temperature gradient, the physical properties of the fluid, and the characteristics of the turbulence. Detailed analytical and numerical results are obtained for the asymptotic state. From authors' summary

**409. Bloom, M. H., and Steiger, M. H., Some compressibility and heat transfer characteristics of the wall jet,** Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engr., 1958, 717–727.

Compressibility and heat-transfer characteristics of a jet spreading out over a plane surface in a stationary ambient atmosphere (termed the "wall jet" by Glauert) are investigated. The major part of the paper deals with laminar flow, both planar and radial, over isothermal and nonisothermal surfaces, in regions away from the emission slot, and with the same jet and ambient gases, including dissociated gases in thermal equilibrium. Thermal solutions in similar form are obtained under the special conditions that the surface temperature is equal to the ambient temperature or that the enthalpy varies monotonically from the surface value to the ambient value. Asymptotic solutions are used to circumvent some lengthy computations. A procedure for treating different jet and ambient gases is indicated and a procedure for treating the turbulent case discussed briefly.

From authors' summary

**410. Koch, R., Pressure drop and heat transfer for flow through empty, baffled, and packed tubes** (in German), *VDI-Forschungsheft* **24,** 469, 44 pp., 1958.

The effectiveness of eddy generators on heat transfer has been investigated. Generators of different types and dimensions were placed in tubes so as to increase the intensity of turbulence of the fluid flow without themselves directly participating in heat transfer. The following generators were tested: Orifices, circular and annular disks, propeller-shaped baffles, helically twisted metal sheets, and different packing materials. Besides heat-transfer and friction coefficients, velocity and temperature profiles as well as skin-friction coefficients have been measured. The heat-transfer coefficients were found to be in no direct relation to the pressure losses. Results are presented in diagrams with Nusselt number versus Reynolds number and versus dimensionless pressure coefficient. With disks and some other generators it was possible to correlate heat-transfer coefficients to skin-friction coefficients. Generators are most effective in fluids with low Prandtl number (gases). With the proper type of eddy generator it is possible to increase the effectiveness of heat transfer so that with the same power for pumping either the heat-exchanging surface can be made smaller for the same rate of heat transfer or, alternatively, more heat can be transferred through the same surface. Orifices appear to give best results. Investigations are rather comprehensive and would obviously assist in developing more effective heat exchangers in cases where most of the heat resistance lies in the heat transfer inside the tubes. H. Schuh, Sweden

**411. Ter-Mkrtchyan, K. A., Investigation of heat exchange processes by the laminar motion of heat carriers in constructions adopted for water heating** (in Russian), *Sb. Nauch. Trudi Erevansk. Politekhn. In-ta* no. 6, 141–149, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 773.

The effect was investigated of free and forced convection on heat exchange processes in heating elements.

Conditions of heat exchange in water-heating systems were obtained by the author empirically for the laminar mode of flow in the following form

$$N = 1.275\,(GP)^{0.15}$$

(where $N$ is Nusselt, $G$ Grashof, $P$ Prandtl number).

The Prandtl number in the experiments varied between 40–100.

To improve the water-heating system it is recommended to increase the temperature of supplied water to 100–103°. The table with results of the investigation shows that the adoption of this recommendation would economize in the consumption of metal (due to a decrease of the heat-exchanging surface area).

V. N. Bogin
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**412. Johnson, D. S., Velocity, temperature, and heat-transfer measurements in a turbulent boundary layer downstream of a stepwise discontinuity in wall temperature,** *J. Appl. Mech.* **24,** 1, 2–8, Mar. 1957.

Results are presented of an experimental investigation of the concomitant thermal and velocity fields occurring when there is a small stepwise discontinuity in the temperature of the wall on which a zero-pressure-gradient, low-speed, turbulent boundary layer has formed. The mean velocity and temperature fields have been measured and local heat-transfer-coefficient values in the streamwise direction have been obtained in the region where the thermal boundary layer has not yet reached the free stream. No overall similarity between the thermal and velocity fields was found. From author's summary

**413. Soberman, R. K., Onset of convection in liquids subjected to transient heating from below,** *Physics of Fluids* **2,** 2, 131–138, Mar.–Apr. 1959.

Experimental investigation of the problem given in the title, the liquids being insulated above. For the case where no external forces other than gravity act upon the liquid author states the formula $Ra = 90.7\,(Ra \cdot Nu)^{0.394}$ for $Ra > 1700$, relating the temperature differences between the top and bottom surfaces of the liquid at which natural convection initiates with the heat input. $Ra$ and $Nu$ are the Rayleigh and Nusselt number which represent nondimensionally the temperature differences and the heat fluxes respectively. Centrifugal forces in rotating liquids inhibit the onset of convection. For this case author gives a graphical representation of the Rayleigh number necessary for the onset of convection as a function of the Taylor number which covers the angular velocity of rotation for several values of the heat flux. In experiments without rotation, mercury and silicone oil were used; the effect of rotation on convection was studied in mercury.

F. Krupka, Czechoslovakia

**414. Sparrow, E. M., and Gregg, J. L., Details of exact low Prandtl number boundary-layer solutions for forced and for free convection,** *NASA Memo* 2-27-59E, 45 pp., Feb. 1959.

Exact numerical solutions of the laminar-boundary-layer equations for the Prandtl number range appropriate to liquid metals (0.003 to 0.03) are detailed. Consideration is given to both (1) forced convection over a flat plate for uniform wall temperature and for uniform wall heat flux and (2) free convection over an isothermal vertical plate. The new solutions are tabulated in detail. Heat-transfer and shear-stress characteristics and temperature and velocity distributions are presented. The heat-transfer results are correlated in terms of dimensionless parameters that vary only slightly over the entire liquid-metal range. Previous analytical and experimental results are surveyed and compared with the new exact solutions.

From authors' summary by M. J. Goglia, USA

**415. Glaser, P. E., and Blau, H. H., Jr., A new technique for measuring the spectral emissivity of solids at high temperatures,** *Trans. ASME* **81C** (*J. Heat Transfer*), 1, 92–94, Feb. 1959.

Principles underlying emissivity measurements in solid materials at temperatures up to 3500 K, and conditions for carrying out these measurements are described. Advantages of using an imaging furnace (solar furnace) for this application are pointed out and the necessary optical system described. A shutter for separating emitted and incident radiation, an aperture-limiting cylinder for temperature control and the calibration of a spectrometer by a black-body reference standard are explained. The paper is purely descriptive and gives no technical details.

A. Whillier, South Africa

**416. O'Sullivan, W. J., Jr., and Wade, W. R., Theory and apparatus for measurement of emissivity for radiative cooling of hypersonic aircraft with data for Inconel and Inconel X,** *NACA TN* 4121, 48 pp., Oct. 1957.

The importance of radiation as a means of cooling high-supersonic- and hypersonic-speed aircraft is discussed to show the need for measurements of the total hemispherical emissivity of surfaces. The theory underlying the measurement of the total hemispherical emissivity of surfaces is presented, readily duplicable apparatus for performing the measurements is described, and measurements for stably oxidized Inconel and Inconel X are given for the temperature range from 600 F to 2000 F.

From authors' summary

**417. Votta, F., Jr., and Walker, C. A., Condensation of vapor in the presence of noncondensing gas,** *AIChE J.* **4,** 4, 413–417, Dec. 1958.

The systems water-air, water-carbon dioxide, water-helium, and *n*-propanol-carbon dioxide were condensed inside a vertical 1-in. tube 42 in. long. A modification of the Colburn-Hougen theory is proposed wherein a single heat-transfer coefficient is used together with a driving force based on the availability concept. Good agreement between the data and theory is indicated. Data and derivations are not included in paper, but are deposited with ADI.

A. C. Mueller, USA

**418. Struzer, L. P., Problem of the precision of the determination of the evaporation by the method of thermal balance** (in Russian), *Trudi Gos. Gidrolog. In-ta* no. 54 (108), 80–91, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5574.

This is a detailed statistical investigation of the exactness of the determination of evaporation $E$ by the formula emerging from the equation of thermal balance of the underlying surface and the similarity of the processes of turbulent heat and humidity exchange in the atmospheric layer next to the earth

$$E = (B - P)/(1 - g\Delta t/\Delta e) \qquad [1]$$

where $B$ is the radiation balance of the underlying surface, $P$ the flow of heat into the soil, $\Delta t$ and $\Delta e$ are the difference between the temperature and the elasticity of the water vapor in the air layer next the earth, $g$ a dimensional coefficient. As initial sources of material, use is made of the results of the mass-balance measurements at Dubovka in the Rostovsk region [Expedition of the Principal Geophysical Observatory, 1953] and at Endla, EsthonianSSR [Expedition of the State Hydrological Institute, 1954]. The main results of the work were the following: (1) For obtaining true conclusions regarding the precision of the determination of $E$ by formula [1] it is essential to consider the correlation between the numerator and the denominator in this formula. (2) The errors in determination of $E$ by formula [1] are on an average 1.5–2.5 times less than the errors in determining $E$ by the diffusion method. (3) If results of measurements averaged for 10 minutes are accepted for the initial data for the observations, while the criteria for sufficient accuracy would be met by the requirement that in 80% of all the cases the relative error for the determination of $E$ should not exceed 20%, then five observations in 24 hours would be sufficient for the determination of a 24-hr day total evaporation rate; when determining the 24-hr daily evaporation total, 30 observations suffice; when determinations are for each hour, fifteen observations in 24 hours are adequate.

L. S. Gandin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**Book—419. Frank-Kamenetzki, D. A., Mass and heat transfer in chemical kinetics [Stoff- und Wärmeubertragung in der chemischen Kinetik],** Berlin, Springer-Verlag, 1959, xv + 224 pp. DM 28.50.

This book is a German translation by J. Pawlowski of a monograph published in Russian in 1947. An English translation has been published in 1955 by Princeton University Press [AMR 9 (1956), Rev. 3092]. The book represents an analytical treatment of the interaction of mass and heat transfer with reaction kinetics. Author comes from the school of the Russian Nobel prize winner, N. N. Semenov, and has, himself, made essential contributions to the development of this field.

The book contains the following chapters: Introduction; Diffusion kinetics; Influence of the Stephan flow; Nonisothermal diffusion; Chemical fluid dynamics; Dimensional analysis of combustion; Temperature distribution in a reacting mixture and steady theory of heat explosion; Flame propagation; Heat balance in heterogeneous exothermal reactions; Periodic processes in chemical kinetics. Author starts with a discussion of the interaction of diffusion and convection processes with heterogeneous chemical reactions occurring on free surfaces and in porous materials. He establishes in this connection the regimes in which such a process is diffusion or kinetic controlled. He proceeds to combine it with a heat-conduction process, adding thermal diffusion and the influence of the displacement flow often connected with a heterogeneous reaction (Stephan flow). He proposes to obtain information on the detailed structure of turbulence from such a chemical process on the basis of the similarity between turbulent heat, momentum, and mass exchange. This chapter may be found controversial by fluid dynamicists. Homogeneous combustion, ignition, and flame propagation are finally investigated.

The Russians have made special attempts to perfect the analysis of problems discussed in this book, and the present volume gives an excellent treatment of those methods on a unified basis. The models on which the analysis is based are often simplified by restricting consideration to a one-dimensional situation and by assuming simplified relations describing chemical kinetics (use of Arrhenius equation). The results of the analyses are compared with experimental information. The book contains also a large number of references of original Russian papers. The German translation follows the original text quite closely.

E. R. G. Eckert, USA

**420. Madden, A. J., The influence of heat transfer on mass transfer at low pressures,** *AIChE J.* **5,** 1, 135–136, Mar. 1959.

Discussion of a paper by Sherwood and Cooke [AMR 11 (1958), Rev. 3774] concerns errors in the interpretation of any one of the following mutually interdependent quantities: surface temperature, accomodation, coefficient, evaporation coefficient. Discussor presents his version of the heat balance of a sphere undergoing sublimation into highly evacuated surroundings, and shows that the original authors' statement about surface temperature was in error; with discussor's correction, the evaporation coefficient, determined from authors' experiments, would be unity. In their closure, Sherwood and Cooke state that they already had started on a re-evaluation, theoretical as well as experimental, of their previous findings, which may yield an accomodation coefficient of 0.41.

E. F. Lype, USA

**421. Kreith, F., Taylor, J. H., and Chong, J. P., Heat and mass transfer from a rotating disk,** *Trans. ASME* **81C** (*J. Heat Transfer*), 2, 95–105, May 1959.

A naphthalene disk was rotated in free air with and without a larger stationary parallel surface, and the average mass-transfer coefficient was computed as a function of speed from the loss in weight. Since the Schmidt number for naphthalene-air was 2.4, according to the heat and mass transfer analogy the observed Sherwood numbers are also the Nusselt numbers corresponding to a Prandtl number of 2.4 at the same Reynolds numbers. The observed Sherwood numbers agree closely with laminar theory up to about 200,000 radial Reynolds number and with heat-transfer results of Cobb and Saunders.

A larger parallel stationary surface, distant $y$ from the disk of diameter $d$, cuts the transfer coefficients to 92% of the free air value when $y/d = 0.25$, to 80% for $y/d = 0.04$, and much more rapidly thereafter to 0 at 0.

Derivations are given for the laminar and turbulent flow theory cases. C. F. Bonilla, USA

**422. Wolfe, W. A., Transient response of heated air in an enclosure with heat losses,** *Trans. ASME* **81C** (*J. Heat Transfer*), 1, 19–23, Feb. 1959.

Author solves the one-dimensional heat conduction equation for a slab in contact with two well-stirred fluids. The temperature of one fluid remains constant, while the temperature of the other fluid varies as heat is extracted from it. The analysis is primarily concemed with determining the coefficients of nonorthogonal eigenfunctions used in the series solution. Using Laplace transforms one can obtain the same solution more directly. Numerical results are presented. E. H. Wissler, USA

**423. Nagiev, M. F., and Karamzin, P. V., An experimental research on heat transfer processes in a tube-in-tube type of exchanger** (in Azerb.), *Izv. Akad. Nauk AzerbSSR* no. 2, 23–35, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 776.

A means of intensifying the heat transfer in a heat exchanger of the "tube-in-tube" type consists of the application of circular partitions on the inner surface of the outside tube. The liquid where the diaphragms are fixed flows in the gas between the outer surface of the inner tube and the diaphragm. The apparatus for the investigation is described and results are given for such heat exchanger with water as the medium. The total coefficient of heat transfer was found to increase by 3–5 times.

The analysis of the results, presented in tables, shows that the increase of the gap up to some point increases the coefficient of heat transfer; beyond this point further increase of the diaphragm diameter effects a drop in the coefficient value. Author notices only the existence of the critical cross section area of the diaphragm. V. N. Bogin

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*Translation, courtesy Ministry of Supply, England*

## Combustion

(See also Rev. 486)

**424. Chang, C. J., and Thompson, A. L., and Winship, R. D., Ignition delay of propane in air between 725–880°C under isothermal conditions,** Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 431–435.

A flow tube rig has been used to study influence of turbulence, fuel/air ratio and oxygen concentration upon ignition delay (time between first contact of reactants and formation of a visible flame). Measured ignition delay was considered to be chemical delay.

Effect of intensity of turbulence in air stream with $Re$ of 2,000–14,000 was negligible. Ignition delay was virtually independent of fuel/air ratio and of air velocity when other parameters were kept constant. It decreased with increase of air temperature according to Arrhenius-type equation with a "global" activation energy of about 47 kcal/g mole. In general the ignition delay varied inversely as the 0.74 power of the oxygen concentration.

Authors claim that results extend work of Frokaw but are only preliminary, and propose further tests with preheating of fuel.

R. Lang, England

**425. Rose, H. E., and Priede, T., Ignition phenomena in hydrogen-air mixtures,** Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 436–445.

Paper deals with experimental study of changes in electrode configuration, electrode material and rate of energy release upon ignition energy. High-speed oscillograph has been used to measure spark discharge characteristics. Experiments cover electrode separations greater and less than quenching distance of mixture. Hydrogen/air mixtures of 10, 20, 30, 40, 50 and 60% hydrogen concentration at 750-mm Hg pressure were used. Most detailed work was with the 50% mixture.

Authors challenge prevailing opinion that minimum ignition energy is independent of experimental details of test. They find that it decreases with (a) reduction of electrode size, (b) electrode material in the following order: platinum, aluminum, silver, cadmium, (c) increase in value of series resistance in circuit.

Effect of most of factors can be explained qualitatively according to thermal considerations but electrical influences affecting ignition are time interval during which spark channel remains in a conducting state after energy release and voltage level at which energy is being released; both being dependent on parameters of circuit. R. Lang, England

**426. Wojcicki, S., Flames stabilization in a surface layer** (in Russian), *Bul. Pol'skii Akad. Nauk, Otd. (IV)* **4**, 4, 305–307, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 236.

Stabilization of flames of a combustible mixture by agitation of the mixture by means of badly streamlined obstacles does not secure a steady flame at high velocity streams, causing big losses of the static pressure in the chamber. The author, in conformity with the known method of stabilization in a boundary layer around a streamlined body [Tsien Hsue-shen, *J. Amer. Rocket Soc.* no. 6, p. 81, 1950] attempts a solution by determining the general criterion of a steady-flow in terms of stabilization by means of the boundary layer originating on the surface of a plate placed parallel to the stream. The following physical model of the process is considered. The velocity distribution in the boundary layer is from nil, at the vicinity of the plate, up to the full speed of the stream, and consequently somewhere between these two limits a layer of mixture exists whose velocity is smaller than the velocity of the laminar combustion. The face of flames stabilizes in the place where the thickness of the layer has some critical value. The heat transferred to the plate from combustion products flows by convection to its frontal edge and is exchanged with streams of fresh mixture. The author proposes the following formula correlating conditions of the deflector, heat exchange and spreading of the flames

$$P_u = KP_s^{\alpha}\left(\frac{\lambda\delta}{EAM^2}\right)^{\beta}$$

where $P_u$ and $P_s$ are Peclet's criteria related to the velocity of stream and the velocity of the laminar combustion respectively; $E = g\kappa R\mu$ ($g$ acceleration of gravity, $\kappa$ entropy exponent, $R$ gas constant, $\mu$ viscosity of the mixture); $\lambda$ heat conductivity of the plate; $\delta$ thickness of the plate; $M$ Mach number of the mixture stream; $A$ the distance from frontal edge of the plate to the flame

face; $K$, $\alpha$ and $\beta$ nondimensional constants. The constants have been determined as results of experiments in the range of Reynolds number from 1540 to 27,820 and of Mach numbers $M$ from 0.0066 to 0.0232, and the equation takes the form

$$P_u = 1.05 \times 10^{-44} P_s^{8.1} \left( \frac{\lambda \delta}{EAM^2} \right)^{3.9}$$

The experiments have been carried out with a lighting gas-air mixture with steel and copper plates (deflectors) and dimensions: $2 \times 89 \times 202$ mm. The general equation correlating velocity of stream $u$ and velocity of a laminar combustion $S$ has the form

$$u = 2 \times 10^4 SA^{0.30} (\lambda T \delta)^{0.46}$$

where $T$ is the temperature of advancing mixture.

A. I. Fedorov

*Courtesy Referativnyi Zburnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**427. Merk, H. J., Analysis of heat-driven oscillations of gas flows. Part V. Influence of heat transfer in the burner ports on the stability of combustion of premixed gases,** *Appl. Sci. Res. (A)* **8,** 1, 1-27, 1958.

Author continues the mathematical attack on sound production in flames by means of the development of transfer functions linking the energy release rates to acoustic energy. In this instance, he considers the effects of heat transfer to the premixed gases from the burner ports by setting up simplified models of the heat transfer system and estimates the resulting transfer functions describing the temperature of the gas issuing from the ports. This is then inserted in expressions similar to those obtained in previous papers in this series [Same author, ibid, **7,** 175-204]. Accordingly, he is able to produce explanations for some of the effects on flame noise which arise from variations in materials used in burner ports, from cooling the ports, etc. M. A. Mayers, USA

**428. Konakov, P. K., Filimonov, S. S., and Khrustalev, B. A., On calculation of heat exchange in boiler furnaces** (in Russian), *Teploenergetika* no. 8, 48-53, 1957.

The aim of this paper is to develop a means for the calculation of temperatures in steam-boiler combustion chambers, without having recourse, as is usual in other formulas, to such conventional quantities as the "reduced degree of blackness," etc., so difficult to evaluate quantitatively.

To this end authors introduce in the furnace heat balance the so-called "radiation temperature," due to Golitzin and defined by him as the temperature of an absolute black body radiating the same unit heat flow as the considered source, in this case the furnace gases.

This radiation temperature $T_r$ is also very difficult to calculate. Authors avoid the difficulty by making use of the "equilibrium layer," introduced by them in a previous paper as the layer near to any radiation surface in which radiation temperature $T_r$ equals the kinetic-molecular temperature of the furnace gases $R_d$.

Several graphs containing experimental data show clearly that the ratio $z = T_d/T_1$, $T_1$ being the absolute temperature of the gases leaving the furnace, is widely independent of the furnace heat load, but depends on the absorptivity, the screening degree and the uncleanliness of the radiation surface, as well as on the fuel burned in the furnace. By using this ratio authors obtain an algebraic equation of the fourth degree in the ratio $T_1/T_t$, ($T_t$ being the absolute adiabatic combustion temperature), containing only 6 empiric coefficients instead of the usual 15, in similar equations developed for the same purpose. They recommend their equation for calculation of the furnace temperature, as well as for the temperatures of the different gas layers in the furnace.

Authors express the desire that further experiments improve this equation by introducing in its coefficients criterial quantities related to the vorticity caused by the disposition of the nozzles, to the concentration of the fuel particles, and to their granulation.

L. G. Hamburger, Roumania

**429. Gurvich, A. M., and Shaylov, Yu. Kh., Methods of calculating the temperature gradient in combustion products of an explosion in a closed spherical container** (in Azerb.), *Izv. Akad. Nauk AzerbSSR* **4,** 3-15, 1954; *Ref. Zb. Mekh.* no. 1, 1958, Rev. 219.

Experiments in the course of thermodynamical investigation of the explosion in a spherical container with a central detonation (a bomb) have shown that the temperature of the center, at a moment of maximum pressure of the explosion, is several hundreds degrees higher than the temperature of gases adjacent to the container walls.

The temperature gradient, as it is known, reduces a magnitude of the maximum explosion pressure with respect to one obtainable at the uniform temperature distribution. The calculations show that a correction factor of the maximum pressure for a temperature gradient rarely exceeds 1% but depends considerably on the composition of the combustion product. Author considers some methods of calculating the correction factor, as well as a calculation of a temperature distribution with respect to the radius of the container.

The volume of the container is assumed to be divided into a series of thin-wall concentric spheres centered at the detonation point. The parameters describing the state of the combustion products in each layer are determined on the following assumptions: (1) the increase of the pressure in the bomb is proportional to the mass of the burning mixture; (2) the compression in each elementary sphere up to burning is adiabatic; (3) the combustion in each layer proceeds at a constant pressure, without loss of heat, and the products of combustion are in full chemical equilibrium, (4) the final compression of the gas in the elementary spheres up to its maximum explosion pressure proceeds adiabatically.

An approximate method of calculation is given by an example.

V. S. Kutlyarov

*Courtesy Referativnyi Zburnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**430. Millan, G., and Da Riva, I., Distribution of radicals in laminar flames, Part I, Criterion of validity of the steady-state assumption,** AFOSR TN 59-626 (Instituto Nacional de Tecnica Aeronatuica Esteban Terradas, Madrid; ASTIA 217 811), 36 pp., Jan. 1959.

The determination of the distribution of the chemical radicals in the sine of the flames constitutes one of the basic problems in the study of these.

Von Kármán and Penner have proposed the extension to this case of the steady-state assumption, used with success in other problems of chemical kinetics. However, a proper criterion to determine in what cases the above assumption can be applied with sufficient guarantee is not yet available.

Authors demonstrate that the applicability of the assumption depends on the value of a certain dimensionless parameter in which the effects of reaction and diffusion of the radicals are combined.

Also, a method of recurrence is developed which enables successive approximations for the distribution of the radicals to be obtained from that corresponding to the steady state.

Finally, a study is made of a mathematical model which, preserving all the properties of the flame, enables an easy comparison of the exact solution with the approximate ones obtained by means of the proposed methods. From authors' summary

**431. Da Riva, I., and Millan, G., Distribution of radicals in laminar flames, Part II, Application of the criterion of validity of the steady-state assumption to several flames,** AFOSR TN 59-627 (Instituto Nacional de Tecnica Aeronautica Esteban Terradas, Madrid; ASTIA 217 812), 51 pp., Jan. 1959.

The object of the present report is to apply the criterion on the validity of the steady-state assumption set out in Part I (see preceding review) to various cases corresponding to flames studied by different authors. For it, the differential equation deduced for the concentration of the radical is integrated by means of the perturbation method set out in the above-mentioned reference. With a view to simplifying the numerical calculation, the concentration of the principal species and of the radicals distinct from that under consideration, if existent, have been approximated by means of appropriate functions.

The two first perturbations were normally sufficient to evaluate the accuracy with which the steady-state assumption enables the concentration of the radicals to be calculated.

The criterion set out makes it possible to prove that the steady-state assumption is sufficiently approximate to calculate the concentration of the radicals in the following cases: Ozone flame, hydrogen radical in the hydrogen-bromine flame, and hydrogen flame. On the contrary, in the case of the bromine radical in the hydrogen-bromine flame and particularly in the hydrazine flame, the parameter for the validity of the assumption is very small and consequently the method of perturbations does not converge and the steady-state assumption for the concentration of the radicals gives large deviations with respect to their actual distributions.

From authors' summary

**432. Hardcastle, J. W., A theoretical analysis of multistage reaction rate controlled systems,** Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 697–704.

Author develops equations describing multistage, homogeneous, adiabatic reactors and applies them to a two-stage reactor burning iso-octane in air. Investigating conditions for minimum reactor volume, author finds that combustion should be staged, but fuel injection should not. Reaction in each stage is stable if overall efficiency of entire system is sufficiently high. Reviewer feels that analysis of systems with more than two stages, using high-speed computers, would be of interest. P. M. Treuenfels, USA

**433. Millan, G., Da Riva, I., and Sanz, S., Combustion of fuel sprays,** AFOSR TN 59-629 (Instituto Nacional de Tecnica Aeronautica Esteban Terradas, Madrid; ASTIA 217 814), 27 pp., Jan. 1959.

The method proposed by Probert for the study of the evaporation of sprays is applied to the analysis of the combustion of a fuel spray burning in an oxidizing atmosphere. The study is applied to various typical cases, corresponding to the starting and the stopping of the injection, as well as to the continuous functioning, and to the cases of periodical injections of short duration.

The Rosin-Rammler function of size distribution, used by Probert, is substituted here by that of Mugele-Evans, which, by limiting the maximum size of the droplets, enables a better approximation to the real distributions.

Some general conclusions of a qualitative nature are obtained regarding the most suitable characteristics of a spray. The great influence that the distribution function and the medium size of the droplets have on the processes under consideration is also shown.

The lack of experimental data constitutes an important difficulty in judging the validity of the model considered.

From authors' summary

**434. Telegin, A. S., and Kitaev, B. I., Study of the structure of burning jets with the aid of a timeglass** (in Russian), *Trudi Ural'skogo Politekhn. In-ta* Pap. 53, 1955, 7–21; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5076.

High-speed photography and a timing glass were the means employed for the study of the changes with time of the structure of burning jets. The photographs obtained enabled the relationship to be found between the length of the jet (of flame) and the velocity of the gas flow. Some deductions are also made regarding the mechanism of the diffusion burning of the gas.

A. E. Kadyshevich
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**435. Hall, A. R., Experimental temperature gradients in burning drops,** Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958, New York, Academic Press, 1959, 399–406.

With fine wire thermocouples author measured the temperature at two points in a burning fuel droplet one millimeter in diameter. He was then able to estimate the temperature gradient within the drop and compute the heat flow from surface to center. He found that during the first half of the burning time over half the heat transferred to the droplet is conducted away from the surface and results in temperature rise rather than evaporation. The resulting changes in evaporation constant and density must be taken into account in the theoretical description of droplet burning rates. One consequence is that the effect of pressure on true mass burning rate is less than the apparent experimental value. These results are interesting but reviewer still worries about applicability of work on large single droplets to the applied problems in burning large numbers of small droplets. J. B. Fenn, USA

**436. Sanchez Tarifa, C., and Perez del Notario, P., Combustion of monopropellant droplets—theoretical results,** AFOSR TN 59-463 (Instituto Nacional de Tecnica Aeronautica Esteban Terradas, Madrid; ASTIA 215 268), 51 pp., Dec. 1958.

Authors study the following problems:

Extension of the integration method for overall reactions of the order and Lewis-Semenov numbers different from one.

Comparison of the results for second-order chemical kinetics with those obtained by means of numerical integration of the equations.

Results of the investigation for first- and second-order chemical kinetics. Study of the principal variables of the process: burning rates, evaporation constants, flame front radius, reaction zone thickness, maximum temperatures, etc., in functions of the principal parameters that influence the process, such as initial diameter of the droplet, activation energy, temperature at the infinite, pressure, etc.

Numerical application for hydrazine, taking the decomposition reaction model proposed by Adams and Stock.

Analysis and discussion of the results conclude the paper.

From authors' summary

**437. Perez del Notario, P., and Sanchez Tarifa, C., An experimental investigation on the combustion of monopropellant droplets,** AFOSR TN 59-628 (Instituto Nacional de Tecnica Aeronautica Esteban Terradas, Madrid; ASTIA 217 813), 24 pp., Jan. 1959.

In the present work authors present the results of an experimental investigation to obtain the velocities of combustion of monopropellant droplets within an inert atmosphere. This investigation was performed to check the theoretical results previously obtained. [See preceding review]. From authors' summary

**438. Hottel, H. C., Williams, G. C., and Bonnell, A. H., Application of well-stirred reactor theory to the prediction of combustor performance,** *Combustion and Flame* **2,** 1, 13–34, Mar. 1958.

It is shown that some gross performance characteristics of combustion chambers can be simulated by conceptual models composed of interacting elements the performance of each of which can be inferred from a knowledge of well-stirred reactor behavior. Analyses are made of three different models to show the effect of element interaction due to: (1) pressure differences between elements, (2) recirculation between elements, and (3) nonuniform fuel oxidant

ratio distribution. The predicted performance of these models exhibits discontinuities and instability phenomena paralleling those found experimentally. Experimental work to date indicates the utility in analyzing high-output combustion chamber performance of models based on simple combinations of well-stirred reactors.

From authors' summary

**439. Spalding, D. B., Combustion in liquid-fuel rocket motors,** *Aero. Quart.* **10,** 1, 1–27, Feb. 1959.

Author develops an idealized one-dimensional model of a liquid-fuel rocket motor with the objective of guiding the development of real rockets. Model is based on four physical laws: droplet vaporization, droplet drag, chemical reaction, and mass conservation. The forms used came from author's earlier publications, including his 1955 book [AMR **9** (1956), Rev. 578]. Predicted performance is analyzed for a number of cases, with reasonable conclusions.

Reviewer thinks this model is a good basis for exploratory thinking, as long as it is used intelligently. Paper is well-written and easy to understand. R. R. Hughes, USA

**440. Barrere, M., Moutet, A., and Sarrat, P., Measurement of the characteristic time of the progress of combustion in a rocket combustion chamber using liquid propellants** (in French), *Rech. Aéro.* no. 60, 29–40, Sept.–Oct. 1957.

A method is described for determining the combustion time and total residence time of the gases in a rocket chamber as related to the coupling of the propellant feed system and the combustion chamber during low frequency instability. These characteristic times are deduced from pressure measurements following abrupt changes in propellant flow, on the basis of two models: one assuming a concentrated combustion zone, the other a first-order monopropellant decomposition.

The method, cleverly conceived, is capable of leading to a better understanding of combustion instabilities but is still a long way from characterizing the very complicated processes of injection, atomization, mixing, ignition and combustion actually occurring in a liquid propellant motor, and involved in the coupling of feed system resonance with the overall combustion process.

M. Gerstein, USA

**441. Tourin, R. H., Spectroscopic studies on temperature gradients in flames,** *Combustion and Flame* **2,** 4, 353–364, Dec. 1958.

The intensity distribution in the i.r. emission spectrum of a flame depends to a large extent on self-absorption within the flame. This self-absorption depends not only on the magnitude of the spectral absorption coefficients, but also on the temperature gradient along the optical path through the flame. Calculations were carried out to obtain estimates of the radiation contributions to the 4.3 micron emission band of carbon dioxide from zones of a flame at various temperatures, for typical temperature distributions encountered in practice. The calculations were based on $\Sigma_u + -\Sigma_g +$, $\Pi_u - \Pi_g$, etc., vibrational transitions of the form $0n^m1 - 0n^m0$ (where $n = 0, 1, 2$, etc.), which have been shown to predominate in this spectral region, using measured emissivities of carbon dioxide. The temperature dependence of rotational energy distribution was accounted for in each vibrational transition. The calculated spectral contours were compared with measured spectra obtained with a special burner in which known temperature gradients could be set up at will. The results indicate that this technique may prove a useful tool in analyzing temperature distributions within a flame. From author's summary

**442. Williams, K. G., Johnson, J. E., and Carhart, H. W., The vertical tube reactor—A tool for study of flame processes,** Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958, New York, Academic Press, 1959, 392–398.

Cool flames have no practical application as yet. They have been difficult to create and maintain in the laboratory. Consequently they have not received the attention showered on their more energetic relatives. This paper describes a simple reactor comprising a vertical heated tube with packing to smooth the flow. It provides stable and reproducible flames in most of their known configurations. Laboratory investigation of cool flames thus becomes more convenient. Chemists will likely be more interested than engineers. The only known applied implication of cool flames is some correlation between the ability of a fuel to form them and its tendency to knock in a spark ignition engine.

J. B. Fenn, USA

## Prime Movers and Propulsion Devices

(See also Revs. 17, 375)

**Book—443. Traupel, W., Thermal turbo-machinery. Vol. I. Thermodynamics and flow analysis [Thermische Turbomaschinen. Erster Band. Thermodynamisch-stromungstechnische Berechnung],** Berlin, Springer-Verlag, 1958, xii + 407 pp. DM 58.50.

This book, first of two volumes, with the second on mechanical aspects to follow, represents a reference or text book covering most thermodynamic and fluid mechanics problems which the design engineer of thermal turbomachinery will encounter.

Compressors and turbines are handled simultaneously wherever it is possible and pertinent, without the customary division between the two types of machines. In addition to analyzing and describing the more elementary problems of fluid flow, cycles, stage design, etc., the book includes chapters on more advanced subjects, such as cascade flow and three-dimensional flow theory of stage design. Throughout, the formulation of results and the development of thoughts are carried out rigorously with reference to basic science and with outstanding clarity. Modern mathematical tools are used. A wealth of useful results of laboratory test information is given.

Extensive bibliographical references are listed at the end of each chapter. The printing of the text, including many mathematical expressions and the reproduction of the numerous curves and illustrations, was accomplished with the customary perfection of Springer Verlag. Reviewer believes that this book, most comprehensive and modern of its kind, will prove indispensable to the engineer working in the field of thermal turbomachinery—if he can read German. Great interest in a book of such proportions would exist in English speaking countries; translation into English should be considered. H. Hegetschweiler, USA

**444. Emin, O. N., Calculations for the characteristics of a turbojet motor (in series) fitted with an air separator for aerodynamic investigations** (in Russian), *Trudi Mosk. Aviats. In-ta* no. 82, 96–105, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4023.

The procedure is described for the calculations for the characteristics of a turbojet motor with an air-separator. The calculations are based on the joint solution of the equations: (a) the consumption of gas in the section behind the turbine, (b) the balance between the work of the compressor and the turbine; (c) the work of the turbine; (d) the consumption of gas in the jet apparatus of the turbine; (e) the connections between the parameters of drag and the thermodynamic parameters of the flow. The system leads to one equation, whose solution is carried out graphically. The results of the calculations agree well with the data of the many experiments performed.

G. A. Varshavskii

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**445. Khutskii, G. I., Reciprocal influence of the stages of a steam turbine of the active type** (in Russian), Avtoref. Diss. Kand. Tekhn. Nauk, Belorussk. Politekhn. In-ta, Minsk, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5273.

**446. Profos, P., Automatic control of steam generators, steam and gas turbines** (in German), *Schweiz. Bauztg.* **77**, 27, 431–441, July 1959.

**447. Ovsyannikov, M. K., Investigations on the conditions of gas exchange in marine two-stroke diesels** (in Russian), Avtoref. Diss. Kand. Tekhn. Nauk, Leningr. Vyssh. Inzh. Morsk. Uchshche, Leningrad, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5274.

**448. Boden, R. H., Ion rocket engine systems—a summary,** *Aero/Space Engng.* **18**, 4, 67–71, 75, Apr. 1959.

**449. Houston, J. M., Theoretical efficiency of the thermionic energy converter,** *J. Appl. Phys.* **30**, 4, 481–487, Apr. 1959.

**450. Webster, H. F., Calculation of the performance of a high-vacuum thermionic energy converter,** *J. Appl. Phys.* **30**, 4, 488–492, Apr. 1959.

**451. Preston-Thomas, H., Some design parameters of a simplified ion rocket,** *J. Brit. Interplanetary Soc.* **16**, 10, 575–583, Nov.–Dec. 1958.

Elementary analysis, restricted to field-free space operation. Ratios of propellant mass, or of power plant mass, to total mass are optimized with respect to various performance parameters, such as transfer time, under conditions of constant acceleration or constant exhaust velocity. Paper is supplementary to previous publication by author in same Journal **16**, p. 508, 1958.

G. H. Markstein, USA

**The 1958 Gas Turbine Progress Report**
*Trans. ASME* **81A** (*J. Engng. Power*), 3, July 1959:

**452. Sawyer, R. T., Introduction,** 215–218.

**453. Herbenar, A. W., and Heckman, G. R., Materials,** 219–225.

Basic requirements for the selection of gas-turbine materials are defined. Alloy categories which meet the basic requirements for gas-turbine materials are discussed in detail. An evaluation of materials for critical gas-turbine components based on performance as well as limitations and future trends is presented. The dependence of future gas-turbine materials on the progress of gas-turbine metallurgy as well as gas-turbine design is strongly emphasized. From authors' summary

**454. Esgar, J. B., Turbine cooling,** 226–233.

Turbine cooling, originally developed because of a shortage of heat-resistant alloys, is of interest for certain applications to permit operation of gas-turbine engines above uncooled temperatures. Specific power output would be increased, and in some cases specific fuel consumption decreased, depending on the engine type. Progress is reported on developments since 1952.

From author's summary

**455. Foster, A. D., Fuels,** 234–243.

A summary of the progress made since 1952 with respect to gas-turbine fuels is presented together with a review of the operating experiences reported on gaseous, liquid, and solid fuels. The technical problems involved are indicated as well as the methods employed for their solution. An appraisal of those areas requiring further developmental study is also included.

From author's summary

**456. Martinuzzi, P. F., Cycle components,** 244–258.

Since 1952, the development of gas turbines has pointed steadily in the direction of greater simplicity, particularly in the arrangement of components in the cycle. Reheat, intercooling, and even recuperation tend to be less used than before, and only where their adoption is well justified. Experience has proved that complicated cycles, which show remarkable advantages on paper, do not work as well as expected in practice.

From author's summary

**457. London, A. L., Compound piston-and-turbine engines,** 259–264.

The prime-mover combination of piston-and-cylinder components with a high-speed exhaust-gas turbine and, in some cases, a centrifugal or axial-flow compressor has assumed a variety of forms. Progress in the development of some of the more notable members of this family of compound engines is presented.

From author's summary

**458. Lancaster, O. E., Aviation,** 265–279.

In the years from 1952 to 1958, the gas turbine became an integral part of the aircraft industries. In fact, the gas turbine has completely revolutionized the industry both in thinking and in designs. Research and testing have been stimulated more than by any previous development. Practicability for commercial use, both as turbojets and turboprops, has been demonstrated, and use in helicopters has begun. Aircraft have been propelled at Mach numbers greater than 2.

The improvements in the engines have been more in the nature of refinements. Specific weights have been reduced to as low as 0.25, specific fuel consumption to 0.76 lb per lb of thrust, and 0.41 lb per eshp. The time between overhaul has been doubled. The centrifugal-type compressor has given way to the axial-flow type.

The two most important innovations were the two-spool units and the variable guide vanes. The most novel developments were the bypass engine and a supercharged turboprop.

From author's summary

**459. Lancaster, O. E., and Bates, C. J., Rocket turbines,** 280–289.

Rocket turbines have come into prominence in the past 20 years chiefly as sources of power for rocket pumps and auxiliary missile requirements. Most are of an impulse type with low efficiencies yet very low weights. Varying from 2 to 20 in. in diam with powers from 1 to 15,000 hp, they are designed to operate for durations of 1 to 5 min with total life of 1 to 50 hr. Although rotational speeds are as high as 100,000 rpm, the tip Mach numbers are lower than in conventional turbojet blades. From authors' summary

**460. Schwartz, F. L., Automotive,** 290–297.

Many experimental models of gas turbines have been built for vehicle propulsion, and indications are that production models may be available within the next decade. Special effort has been devoted in recent years to improving the fuel consumption by adding heat exchangers to the originally proposed simple-cycle gas turbines. If they are to be competitive with reciprocating engines, gas turbines must not only be equal or better in performance, but equal or lower in cost. This would require manufacture in large quantities, and it is very likely that the first production models will be in a low-priced high-production automobile.

From author's summary

**461. Broadley, P. R., Meyer, W. M., Neuhart, D. S., Barlow, E. L., Bond, R. C., Williams, D. S. D., and Cooke, B. W. C., Railroad,** 298–310.

Progress during 1957 on the coal-burning gas-turbine power plant being perfected by the Locomotive Development Committee of Bituminous Coal Research, Inc., is reported. Operating experience

with the Union Pacific Railroad's 4500-hp General Electric gas-turbine-electric units, and the characteristics of the 8500-hp units on order from General Electric are given. The U. S. Army's 30-ton unit, Electro-Motive Division's free-piston engine, several British Railways developments, Soviet designs, Swiss, Czechoslovakian, Swedish, and French progress are reported.

From authors' summary

**462. Sawyer, J. W., and Simpson, H. M., Marine,** 311–343.

This is a progress report on the marine gas turbine and free-piston gas turbine during the 5-yr period 1953–1957. Since the merchant and naval services encompass many similar operating conditions—in spite of many differing requirements—the entire marine field is reviewed in a single paper.

Open and closed-cycle gas-turbine, nuclear gas-turbine, and free-piston gas-turbine prime movers are discussed along the following lines: Applications, operating experience, development, advantages, disadvantages, economics, and the future potential in the marine field. From authors' summary

**463. Skrotzki, B. G. A., Industrial and central station,** 344–351.

Gas turbines have become established components of modern industry. Industrial and central-station units now total 3,614,000 hp installed, planned, or projected, and a wide variety of equipment is available. One generation of commercial industrial gas turbines—the Houdry process—has already become obsolete. Capacity limits of power-generating units are being increased to the 50-mw range, and combinations of gas turbines and steam turbines are offered for 150 mw. Pipeline transport of natural gas and crude oil uses the largest number of mechanical-drive gas turbines. Small gas turbines developed largely for military use have potential for use in industry and commerce.

From author's summary

**464. Godwin, R. P., and Dennison, E. S., Nuclear,** 352–359.

The nuclear gas-turbine plant has recently become the basis for a substantial development program. Because of considerable difficulties, particularly in the areas of heat and radiation-resistant materials, from 5 to 7 years must elapse before any real accomplishment can be demonstrated. The most attractive line of development from a cost, efficiency, and weight point of view appears to be the single-fluid gas system, discussed in detail. The case for the optimum gas is not clear-cut. Thermodynamic, system, and bearing and seal problems are considered.

From authors' summary

## Magneto-fluid-dynamics

**465. Lykoudis, P. S., The matching of the viscid and inviscid regions for the stagnation magnetic flow,** *J. Aero/Space Sci.* **26,** 5, 315–317 (Readers' Forum), May 1959.

The effect of a magnetic field on the flow near the stagnation point of a bluff body traveling with hypersonic speed through a conducting fluid is discussed. The paper is very difficult to read as a result of over-condensation. K. Stewartson, England

**466. Hess, R. V., Some basic aspects of magnetohydrodynamic boundary-layer flows,** *NASA Memo* 4-9-59L, 42 pp., Apr. 1959.

Author gives a running commentary on several previous papers on this subject, reviewing their assumptions and comparing their results. Attention is limited to incompressible fluids with constant transport properties, and is focused particularly on the circumstances under which the magnetic body force may be approximately derived from a potential, leading to irrotational flow outside the boundary layer. In these circumstances, author treats the magnetic force as analogous to gravity. F. S. Sherman, USA

**467. Polovin, R. V., and Liubarskii, G. Ia., Impossibility of rarefaction shock waves in magnetohydrodynamics,** *Soviet Phys.-JETP* **8,** 2, 351–352 (Letters to the Editor), Feb. 1959. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk SSSR* **35,** p. 510, Aug. 1958 by Amer. Inst. Phys, New York, N. Y.)

**468. Mitchner, M., Magnetohydrodynamic flow in a shock tube,** *Physics of Fluids* **2,** 1, 62–71, Jan.-Feb. 1959.

Effect of a transverse magnetic field on the motion of a perfectly conducting fluid in a shock tube is analyzed. Conservation equations for a magnetohydrodynamic shock are solved to describe the fluid motion in terms of arbitrary initial conditions. The effect of the magnetic field, although qualitatively like a pressure, is always greater than the equivalent hydrodynamic pressure. A magnetic field in the high pressure region alone can produce shocks having Mach numbers, for typical laboratory conditions, of the order of several hundred. Results are shown to be in general agreement with experimental results of others. Paper is a valuable step toward the understanding of complex experimental results in an expanding field which needs some orderly thought.

R. A. Gross, USA

**469. Rikitake, T., Magneto-hydrodynamic oscillations of a perfectly conducting fluid sphere placed in a uniform magnetic field,** *J. Phys. Soc. Japan* **13,** 10, 1224–1230, Oct. 1958.

**470. Totaro, C., On the reflection and refraction in magneto-hydrodynamics** (in Italian), *Atti Accad. Naz. Lincei, R.C. Cl. Sci. Fis. Mat. Nat.* (8) **24,** 3, 310–316, Mar. 1958.

V. Ferraro ["On the reflection and refraction of Alfvén waves," *Astrophysics J.* **119,** 393–404, 1954] attacked the problem of the reflection and refraction of hydromagnetic waves on the separation surface of two different fluids under the following assumptions: the coefficients of conductivity of both fluids are infinitely large, the energetic system is described by means of Euler-Maxwell equations, and the waves are two-dimensional, propagating in the direction of the external magnetic field. Totaro attacks the problem under the assumptions: the coefficients of conductivity are finite, the energetic system is described by means of Euler-Minkowski equations and the hydromagnetic waves propagate in a direction different from that of the external magnetic field. The Euler-Minkowski system is linearized. Moreover, certain assumptions are made concerning the magnitude and analytical structure of the magnetic induction. The problem refers to an incompressible fluid with the usual set of Maxwell equations. The entire space is divided by means of the horizontal plane into two subspaces: that of the incoming and reflected waves and that of the waves which pass through the dividing plane. The system of the governing equations is valid separately in both subspaces, and on the horizontal plane these two systems must have some common aspects. After certain analytical manipulations, author obtains the following results: the refraction angle is given by a simple formula; the phase velocity of the incident and reflected waves are equal; the reflection angle is equal to the incident angle.

M. Z. v. Krzywoblocki, USA

**471. Lindgren, H., The cavitation laboratory of the Swedish State Shipbuilding Experimental Tank** (in English), *Medd. Stat. Skeppsprov., Goteborg* no. 43, 25 pp.

**472. Marks, G., The variational principle for dielectrics** (in Russian), *Byull. Pol'skii Akad. Nauk, Otd. III,* **4,** no. 1, 29–35, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2884.

The variational principle is applied for the establishment of relativistic equations for the motion of an ideal liquid in a charged medium. During the motion of the ideal liquid an investigation is carried out of the Lagrangian $L = \mu c^2 - p$ as an invariant magnitude, where $p$ is the isotropic pressure, $\mu$ the density of the

quiescent mass, $c$ the velocity of light, and a variation of the integral of action is produced $S = \int L\sqrt{g}\, dx$ on the components of the metric tensor $g_{ik}$. As the result, expressions are established for the energy-impulse tensor and the equation of motion of an ideal liquid in the absence of a gravitational field. In the case, however, of the motion of a charged ideal liquid, giving rise to an electromagnetic field, the Lagrangian $L$ is made more complex by terms containing the components of tensors of stresses of the electric and magnetic fields and of the vector potential $\varphi_i$. The variation of the integral of action $S$ on $\varphi_i$ leads to the equations of the Maxwell-Minkovskii electromagnetic field, while variation $S$ on the variable $g_{ik}$ gives a generalized expression for the energy-impulse tensor of the medium and the electromagnetic field. The variational method of investigation may have some applications in the hydrodynamic theory of nuclear reactions.

M. D. Khaskind

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*Translation, courtesy Ministry of Supply, England*

## Aeroelasticity

(See Rev. 406)

## Aeronautics

(See also Revs. 40, 458)

**473. Staufenbiel, R., Contribution for determining the shock velocity of airplanes at landing** (in German), *Dtsch. Versuchsanstalt Luftfahrt Ber.* 71, 38 pp., July 1958.

A simple analytical investigation is made of the landing of an airplane under constant drag force. The objective is to find conditions for minimizing the impact velocity of landing while keeping the flight stable. The impact velocity is shown to depend on the product of two factors. One is independent of errors of estimation by the pilot and depends only on the size of airplane and glide approach velocity; the other depends on the errors of estimation by the pilot. The Weber-Fechner error laws governing the estimation of physical quantities is assumed to hold. A simple nonlinear differential equation for the landing velocity is derived and solved by perturbation methods. W. H. Hoppmann, II, USA

**474. Alekseyev, O. I., and Matyazht, A. I., Calculation of the take-off run of an aircraft** (in Russian), *Trudĭ Kazansk. Aviats. In-ta* **31**, 85–90, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1546.

A new method of integrating the equation of the take-off run of an aircraft is suggested, founded on the use of orthogonal polynomials. The method is applicable to an aircraft with any type of propulsion. Execution of the calculation requires preliminary construction of curves for the required and available thrust values, referred to the square of the speed. A numerical example is presented, demonstrating the rapidity of convergence of the process. A. I. Zenkin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**475. Hooper, W. E., Helicopter ground resonance,** *Aircr. Engng.* **31**, 360, 32–39, Feb. 1959.

Paper is devoted to one of the most critical and least understood phenomenon in helicopter design. The subject of ground resonance is of deep concern to rotary wing designers and yet they have few tools with which to safeguard their designs from this self-excited vibration.

The equations of motion developed by R. P. Coleman in his classical paper are evaluated for a particular helicopter configuration and a large number of different combinations of rotor and fuselage damping. These results are displayed graphically and reveal the dependence of the unstable range on rotor and fuselage damping. Some of the conclusions are in disagreement with those reached by Coleman. Both viscous and friction dampers are considered.

Author states that methods of estimating the stability margins of single and tandem rotor helicopters, and a proposal for a stability criterion will be discussed in a future paper. L. Goland, USA

## Astronautics

(See also Rev. 388)

**Book—476. Alperin, M., and Gregory, H. F., editors, Vistas in astronautics,** Vol. 2 (International series of monographs on Aeronautical Sciences and Space Flight), New York, Pergamon Press, Inc., 1959, x + 318 pp. $15.

This volume is made up of the papers presented at the second annual AFOSR Astronautics Symposium, 1958. The various papers are grouped into sections titled: (1) Space environment and vacuum research, (2) Control and propulsion of vehicles outside the atmosphere, (3) Departure, space navigation and re-entry problems, (4) The Earth's Moon. An interesting panel discussion on the uses of manned space flight capabilities is also reproduced.

The many papers (28) present a variety of views and all are interesting. Kuiper's moon pictures are striking. Aside from its cost, the volume is worthwhile. H. N. Abramson, USA

**477. Esses, H., Satellite orbit mechanics,** *Aero/Space Engng.* **18**, 4, 48–54, Apr. 1959.

A survey of satellite orbit mechanics assuming point masses and inverse square field. H. G. Lew, USA

**478. Nielsen, J. N., Three-dimensional satellite orbits with emphasis on re-entry dynamics and oblateness effects,** *Aero/Space Engng.* **18**, 4, 60–66, Apr. 1959.

A study of non-lifting bodies in satellite orbits considers the effects of gravitational field due to the oblateness of the earth, the nonspherical figure of the earth, and the rotation of the earth's atmosphere. Emphasis is on the re-entry phase of the trajectories. Numerical integration indicates the following results: oblateness and atmospheric rotation have a large influence on range and location of impact. H. G. Lew, USA

**479. Szebehely, V. G., Orbit changes and invariants in a Newtonian central force field,** Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 233–238.

Consider a body moving on an arbitrary orbit in a Newtonian central force field and assume that at a certain point of the orbit the velocity vector of the body is changed instantaneously. Paper discusses the new orbit and its relation to the original orbit, as well as energy preserving, angular-momentum-preserving and direction-preserving orbit changes. E. Leimanis, Canada

**480. Suvorov, S. V., Movement of a point on a turning trajectory** (in Russian), *Fiz.-Matem. Sb. Trudĭ Ivanovsk. Energ. In-ta* no. 2, 156–163, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 4958.

Author shows that, by increasing any central force up to a magnitude inversely proportional to the cube of the distance, it is possible to make the material point describe on the plane rotating about the center of forces the very same trajectory which it describes on an immovable plane under the action of the initial force, if the angular velocity of rotation of the movable plane is proportional to the angular velocity of the relative motion, and if the

original conditions are selected with due regard to their relation to the additional force and to the initial conditions of the relative motion. G. K. Pozharitskii

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**481. Chebotarev, G. A., A symmetrical rocket trajectory for a flight around the moon** (in Russian), *Bul. In-ta Teor. Astron., Akad. Nauk SSSR* **6**, 7, 487–492, 1957; *Ref. Zh. Mekh.* no. 1, 1953, Rev. 46.

Principal conditions of a motion are given for a flight of a rocket, which at $t = 0$ starts from Earth, goes around the Moon and back to the Earth's surface, with the assumption that the motion is not damped by the Earth's atmosphere.

Author begins from the following consideration. At the moment $t_0$, let the Moon and the rocket appear on $x$-axis, with the distance between the rocket and Earth $x^\circ$ greater than the distance between the Moon and the Earth $x_1^\circ$ and the velocity of the rocket equal to zero. Neglecting a force of attraction of the rocket by the Moon, the rocket will begin to drop to the Earth along $x$ axis. The disturbing effect of the Moon will deform the straight line trajectory of the rocket, which in consequence, moving from the point $x^\circ$, will appear at the distance $r_{min}$ from the Earth's center. The bigger $\Delta^\circ = x^\circ - x_1^\circ$, the smaller is the Moon influence. By a successive selection it will be possible, therefore, to obtain a result which will fulfil the inequality $r_{min} < R$, where $R$ is the radius of the Earth. If the motion of the Moon were reversed, the rocket moving from point $x^\circ$ would describe a trajectory symmetrical to that obtained formerly. The position and velocity of the rocket at the moment of drop on the Earth's surface will determine values of the initial conditions necessary to find the rocket at the time $t = 0$, at the distance $x^\circ$.

$\Delta^\circ$ was taken for first approximation as 15,600 kms. The numerical integrations were conducted according to Cowell method, with intervals of integration equal to one hour. For $t > 100$ hr, the disturbing effects of the Moon become insignificant and the further motion is considered as undisturbed. The value obtained of $r_{min}$ is 32,975 kms, and the rocket would therefore pass 26,597 kms above the Earth's surface.

In the second trial, $\Delta^\circ = 31{,}600$ kms, and the interval of integration was 2 hrs; $r_{min} = 5169$ kms. The condition of the exact drop on the Earth's surface is $r_{min} = R = 6378$ kms. The principal conditions of a motion around the Moon are described by the following parameters:

$$a = 215{,}200 \text{ kms}; \qquad M = 0^\circ.16;$$

$$e = 0.97598; \qquad \pi = 183^\circ.18$$

The initial velocity is 11,080 m/sec; the total time of flight 236.14 hr. The minimum distance of the rocket from the Moon surface is 29,860 kms. V. S. Novoselov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**482. Allen, H. J., Motion of a ballistic missile angularly misaligned with the flight path upon entering the atmosphere and its effect upon aerodynamic heating, aerodynamic loads, and miss distance,** *NACA TN* 4048, 66 pp., Oct. 1957.

An analysis is given of the oscillating motion of a ballistic missile which upon entering the atmosphere is angularly misaligned with respect to the flight path. The history of the motion for some example missiles is discussed from the point of the effect of the motion on the aerodynamic heating and loading. The miss distance at the target due to misalignement and to small accidental trim angles is treated. The stability problem is also discussed for the case where the missile is tumbling prior to atmospheric entry.

From author's summary

**483. Gazley, C., Jr., The penetration of planetary atmospheres,** ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-27, 11 pp.

The problems of penetrating a planetary atmosphere are reviewed, and techniques for penetration are discussed. These techniques are resolved into two general classes: (a) Gradual entry into the atmosphere with relatively low deceleration loads and heating rates low enough so that the heat may be rejected by thermal radiation from the surface, and (b) direct entry with higher deceleration loads and higher heating rates with the heat being absorbed by the body surface. From author's summary

**484. Koelle, H. H., On the economy and techniques of large booster recovery,** ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-1, 7 pp.

The question of booster recovery for large space-flight operations, which becomes very important with increasing vehicle size and firing rates, is discussed in detail. Such parameters as initial vehicle requirements, recovery cost, booster rotation time, and various correction factors are defined and explained. Simple approximation formulas are derived and evaluated for an arbitrarily selected orbital flight mission. Recovery schemes based on parachutes, wings, turbojets, and combinations thereof are evaluated numerically. From author's summary

## Ballistics, Explosions

(See also Rev. 326)

**485. Brode, H. L., Blast wave from a spherical charge,** *Physics of Fluids* **2**, 2, 217–229, Mar.-Apr. 1959.

Artificial viscosity technique of von Neumann and Richtmyer is used in detailed numerical calculations of the blast field in air round a spherical TNT charge, density 1.5 g/cm$^3$, with central initiation. Results given include (a) nondimensional pressure, mass velocity, wave velocity, temperature and density in the first shock out to $R/\alpha = 4$, where $R$ = shock radius, $\alpha^3 = p_0/W$, $p_0$ = ambient pressure (1 atm), $W$ = total energy release; (b) velocity profiles at 22 selected times out to $tc_0/\alpha = 5.0$, where $c_0$ = air sound speed, pressure (21 times) to 4.2, density (9) to 0.22 and temperature (7) to 0.013; (c) pressure as a function of time at 4 points inside and 5 outside maximum expansion of products; (d) summary space-time diagram of flow to $r/\alpha = 1$ and $tc_0/\alpha = 1.5$. Comparison is made with previous more restricted calculations for same system by other workers and by author for point-source explosions. Reviewer considers this a most informative paper.

S. Paterson, Scotland

**486. Lidov, M. L., Automodel motion of a gas with spherical symmetry in the field of a gravitational center** (in Russian), *Astron. Zh.* **34**, 4, 603–608, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 3769.

In the works of Carrus, Fox, Haas, Kopal [P. Carrus, P. Fox, F. Haas, Z. Kopal, *Appl. J.* **113**, no. 1, 1951] a solution was obtained for the problem of central explosion of Rosh's model for the adiabate indicators $\gamma = 5/3$ and $\gamma = 3/2$. In the present paper, on the basis of concepts of the analysis of dimensions, a more general setting of the automodel problems is presented, regarding the irregular motions of a gas in the field of a gravitational center. For the problem, investigated in the cited paper, two integrals are indicated in a system of ordinary equations, existing for any indicator of the adiabate. For $\gamma = 4/3$ an exact solution of this problem was obtained, expressed in quadratures. The method of setting employed for the automodel problems is founded on analogous so-

lutions presented in L. I. Sedov's book ["Methods of similarity and dimensions in mechanics" Moscow, Gostekhizdat, 1951].

From author's summary
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**487. Chace, W. G., Liquid behavior of exploding wires,** *Physics of Fluids* **2,** 2, 230–235, Mar.-Apr. 1959.

**488. Cox, E. F., Far transmission of air blast waves,** *Physics of Fluids* **1,** 2, 95–101, Mar.-Apr. 1958.

**489. Vorob'ev, L. M., Solution of the basic problems of exterior ballistics,** *Appl. Math. Mech. (Prikl. Math. Mekh.)* **22,** 3, 481–492, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Paper describes method of integrating systems of ordinary differential equations yielding approximate analytic solution. Results are applied to equations of rocket and of free projectile acted on by uniform gravity and drag. J. Lorell, USA

**490. Kapur, J. N., The internal ballistics of a high-low pressure gun after burnt,** Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagapur, 1956, 209–220.

Author corrects Corner's theory of interior ballistics after "burnt" in high-low pressure gun; error was neglect of energy still passing from chamber to bore during this phase. This would cause error of order 15% in velocity if "all burnt" occurred early in travel. Fortunately the advantages of this type of gun are associated with "all burnt" time near the end of shot travel, and then the error is small. Formulas of present paper are applicable whether or not the burning phase uses the "isothermal approximation." J. Corner, England

## Acoustics

(See also Rev. 291)

**Book—491. Harris, C. M., edited by, Handbook of noise control,** New York, McGraw-Hill Book Co., Inc., 1957, ix + 997 pp. $16.50.

Noise, by definition, is unwanted sound. It interferes with man's ability to communicate with others, it can become detrimental to man's well being and efficiency and even do permanent harm to his body. Noise control, that is the technique of achieving an acceptable noise environment at the receiving end of a sound source, plays an increasingly important role in the social as well as in the economical field. More and more money is spent annually by industries to combat noise. So far no comprehensive treatment has been available covering the whole realm of noise control.

The editor of this handbook and his collabomtors deserve the credit of having filled this gap with an excellent series of diligent articles covering the entire field in an authoritative manner. Much of the material presented is new. Thorough references to original sources permit the reader to penetrate into more specific details. The handbook will undoubtedly become an indispensable aid for all concerned with noise problems, be they engineers, physicists, architects, otologists or lawyers and compensation experts.

The general grouping of the articles includes properties of sound, effects of noise on man, vibration control, instrumentation and noise measurement, techniques of noise control, noise control in buildings, sources of noise and examples of noise control, noise control of machinery and electrical equipment, noise control in transportation, community noise, and the legal aspects of noise problems. F. E. Borgnis, Germany

**492. Gazarian, Iu. L., The sound field generated by a point source in a layer lying on a halfspace,** *Soviet Phys.-Acoustics* **4,** 3, 237–242, Dec. 1958 (Translation of *Akust. Zh.* **4,** 3, 233–238, July-Sept. 1958 by Amer. Inst. Phys., New York, N. Y.)

For an explosive sound source in shallow water with a sound-conducting bottom ("halfspace") the sound potential is shown by Pekeris [Memoir no. 27, Geological Society of America, 1948] to consist of a contour integral along a branch line and a sum of residues, or "normal modes." Author investigates in detail the frequency dependence of the contour integral, which he terms the "lateral wave," at several layer thicknesses from the source, and shows that at distances not too far from the source the appearance of a normal wave is masked. W. W. Soroka, USA

**493. Cremer, L., and Schwantke, G., On the problem of radiation of flexural waves** (in German), *Acustica* **7,** 1, 329–335, 1957.

The radiation due to a vibrating plate of finite width into a rectangular enclosure open at one side is studied mathematically. The radiation is characterized by the mean square value of the sound pressure, rather than by the normal component of the energy current. The effect of absorption by the walls is taken into account. It is found that the response depends not only on the ratio of sound frequency to cut-off frequency but also on the mode of vibration of the plate. Below the cut-off frequency, therefore, the radiation properties of a given plate are affected by its width and the nature of the enclosure. R. Heller, USA

**494. Polotskii, I. G., and Khodov, Z. L., Velocity of ultrasound in some binary liquid systems and their compressibility** (in Russian), *Sb. Nauchn. Rabot Labor. Metallofiziki, Akad. Nauk SSSR* no. 5, 34–44, 1954; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6403.

Making use of ultrasonic interferometers at temperatures of 20 to 50° and using concentration limits of 0 to 100° a series of measurements of sound were carried out, and the compressibilities computed for a number of binary liquid systems with different characteristics of interaction between the like and unlike molecules. The following four systems were investigated: (1) the benzene-toluene system, in which the forces of interaction between the like and the unlike molecules are approximately the same; (2) the allyl mustard oil-piperidine system, in which the chemical constituents interact mutually; (3) the chloroform-ethyl ether system, in which the forces of interaction are significantly greater between the like molecules than between the unlike; (4) the benzol-nitrobenzol system, in which disintegration of the constituents takes place. In the system benzene-toluene, the compressibility isotherms have a weakly indicated maximum. It is assumed that this is linked with the fact that the interaction between the like molecules is somewhat smaller than between the unlike. In the system benzene-nitrobenzene, the velocity of sound is linearly related to the concentration. In the system chloroform-ethyl ether, the concentration relationship with the velocity of sound differs only slightly from the linear. The compressibility isotherms in the system allyl mustard-oil-piperidine have clearly defined minima at temperatures of 25 and 50°. The occurrence of this minimum indicates a strong interaction of the constituents of the system. It is noted that a study of the adiabatic compressibility of binary liquid systems enabled some deductions to be made regarding the character of the interaction between the molecules.

I. G. Mikhailov
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**495. Dessler, A. J., Interactions between first and second sound in liquid helium,** *Physics of Fluids* **2,** 1, 5–7, Jan.-Feb. 1959.

The reflection coefficient for a small-amplitude second sound wave reflected by a large-amplitude first sound wave front is

derived. Analysis assumes conservation of heat current density and of flow of thermodynamically available energy across the discontinuity at the first sound wave front. Main contribution to the reflection coefficient is shown to be the particle velocity associated with a pressure wave. Author concludes that, if the first sound wave has sufficient amplitude ($\Delta P$), this interaction should be observable in liquid helium.

The case of a small-amplitude first sound wave reflected by a large-amplitude second sound wave front is also analyzed.

M. Morduchow, USA

## Micromeritics

(See also Rev. 277)

**Book—496. Orr, C., Jr., and DallaValle, J. M., Fine particle measurement, size, surface and pore volume,** New York, The Macmillan Co., 1959, xiv + 353 pp. $10.50.

Detailed discussions cover techniques currently used in research laboratories for measurement of size, surface, and pore volume, treating both theory and application. Over seventy techniques are described under the following chapter headings: (1) Significance of measurement techniques and their selection (definition of particle size, surface area, and pore volume, range of the various methods); (2) Particle size by microscopy and sieving (optical and electronic microscopy, automatic scanning methods, methods of mathematical representation, determination of shape factors); (3) Sedimentation for determination of particle size (Stokes and Cunningham formulas, effect of particle shape, various methods of application); (4) Inertial techniques for size analysis (particle trajectories, centrifugal methods, cascade impactor, electrostatic precipitation); (5) Particle size from radiation scattering and transmission (scattering by particles larger than, comparable to, and much smaller than the wavelength of light, light transmission, scattering with absorption, nonspherical particles, instrumental methods); (6) Surface area from permeametry (viscous flow, Kozeny-Carman equation, Knudsen flow, various methods of application and their evaluation); (7) Gas absorption for surface area measurement (Langmuir's theory, low-temperature nitrogen absorption, gravimetric analysis, rate-of-absorption analysis); (8) Measurement of surface area from liquid-phase sorption (fatty acid sorption, exchange sorption of radioactive isotopes, sorption of dyes); (9) Other methods of surface area measurement (suction pressure, heat conductivity, heat of adsorption, solubility, covering power); (10) Pore size and pore-size distribution (direct measurements, displacement methods, gas-flow analysis, vapor adsorption, powder flow properties). An appendix contains 34 tables giving comparison values obtained by various methods on carbon blacks, nickel catalysts, clay minerals, cements, sands, pigments, glass microspheres, metal powders, and other solid particles, which also serve as order-of-magnitude values for unmeasured but similar materials.

This is an authoritative, up-to-date, comprehensive treatise of the subject. Scattered among the text are many items of information on numerous aspects of surface physics and chemistry.

K. J. DeJuhasz, USA

**Book—497. Green, H. L., and Lane, W. R., Particulate clouds, dusts, smokes and mists,** Princeton, New Jersey, D. Van Nostrand Co., Inc., 1957, xix + 434 pp. $11.25.

Detailed treatise on subject is arranged in logical sequence and divided into two main parts: Part I, pp. 3–277, deals with basic physics and physical chemistry of individual suspended particles in gases, and of clouds of particles, with special reference to their formation, stability, optics, aerodynamics, and estimation; Part II, pp. 281–410, deals with industrial and environmental aspects; here, technical details of plants and processes are considered only superficially, the main emphasis being placed on the application of the scientific principles outlined in Part I. Chapter headings are: (1) Introduction to the nature and properties of dusts, smokes and mists; (2) Production of particulate clouds; (3) Some physical characteristics; (4) Optical properties; (5) Coagulation; (6) Deposition and filtration; (7) Sampling and estimation; (8) Diffusion in the atmosphere; (9) Collection by gravitational, inertial and other methods; (10) Health hazards; (11) Atmospheric pollution; (12) Aerosols in nature; (13) Uses of particulate clouds in industry, therapy and agriculture.

The great number of references are given by author and locus, but without title.

This treatise is a valuable aid for academic and industrial research workers, and also for scientists and engineers in general, who desire fundamental information in this field of ever increasing importance; in particular, it is of special value to chemical, atomic energy, mining and other industries where particulate clouds are created or encountered, with their attendant health hazards through smoke, dusts, bacteria and other pollutants. The authors have gathered their information from many fields, and their treatment reflects their active research on a wide variety of phases of the subject.

K. J. DeJuhasz, USA

**498. Banister, J. R., Particulate dynamics research at Sandia Laboratory,** Proc. 6th Midwest. Conf. Fluid Mech.; Austin, Texas, Univ. of Texas Press, 1959, 277–291.

Paper presents conservation of mass, momentum and energy equations in differential form for flow of air with suspended dust particles. The mass of suspended dust per unit volume is comparable to the density of air, and the dust particles are assumed to be of identical size. After indicating the complexity of the problem if dust-air interaction and particles of different size and shape are present, an approximate solution for one-dimensional flow near a stagnation point is developed.

These equations form the basis for the construction of probes for measuring air dynamic pressure and dust momentum flux. Accurate measurements were obtained for particles greater than 20 microns in an air stream of several hundred ft/sec, while a 25% error was found in dust momentum flux for particles of about 10 microns.

The article is clearly written and presents the problem of two-fluid flow of air and a quasi-continuum of particles in a simple and understandable way.

K. Schneider, USA

**499. Platonov, P. N., and Naremskii, N. K., Investigation of the work of centrifugal cyclone-separators** (in Russian), *Trudi Nauchno-Tekhn. o-vo Mukomol. i Krupyan. Prom-sti i Elevat. Kh-va* no. 5, 3–32, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6876.

The work was investigated, on an experimental apparatus, of a cyclone by measuring the hydraulic resistance of the cyclone (the energetic indicator) and the magnitude of the removal of material from the cyclone (the technological indicator). It was established that the hydraulic resistance of the cyclone falls with an increase in the concentration of the solid phase. The minimum magnitude for the discharge from the cyclone is observable when the inlet-flow velocity lies in the limits of 11–18 m/sec. To bring together the air trajectories and the solid phase, which has the effect of improving the settling out of the solid phase, the angle of inclination of the directing apparatus should be 12°. The minimum removal of particles corresponded with conicality angles of 16°40′–25°50′. Increase in the height of the cylindrical portion of the cyclone somewhat reduced its resistance, not influencing the technological effectiveness. The optimum relation between the diameters of the exhaust pipe and the cylindrical portion of the cyclone was found to be 0.6. Increase of the diameter of the cylindrical part of the cyclone increased its absolute resistance. A series of empirical relationships is put forward for the deter-

mination of the basic dimensions for a centrifugal separator for use in machinery for pneumatic transport.

U. Ts. Andres

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**500. Pakhuta, S. A., Analysis of the depth of limiting equilibrium in relation to the surface loading** (in Russian), *Uch. Zap. Belorus. In-ta* **19**, 82–92, 1954; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2182.

The limiting equilibrium of a homogeneous, heavy granular medium is investigated, in the presence of friction and cohesion, and bounded by an inclined surface over which a pressure acts, uniformly distributed over the surface and the normal whereof is inclined from the vertical at the angle of repose of the material. As is known, if the angle of inclination of the surface to the horizontal is greater than the angle of friction of the soil, a granular substance will not be able to remain at rest, if its extension in depth exceeds a certain limiting value $h$. The author derives a formula for $h$ (not quite correctly calling this quantity the "depth of limiting equilibrium") and presents some considerations on the possibility of formation of folds in the terrestrial crust by disturbance of the limiting equilibrium. It should be pointed out that the formulation of the problem (the "generalised Rankin problem") in the absence of pressure on the free surface of the medium was first solved by S. S. Golushkevitch ["The two-dimensional problem of the limiting equilibrium of a granular medium," Moscow-Leningrad, Gostekhizdat, 1948].

G. S. Shapiro

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**501. Krimanov, A. D., Determination of speed of the air required in the operation of dust-particle transmission pipes** (in Russian), *Nauch. Trudi po. Vopr. Gorn. dela Mosk. Gorn. In-ta* no. 16, 101–113, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 378.

Experimental results are given of tests determining the influence of some factors on the speed of transmission of dustlike particles through pipes by moving air. The actual speed of transmission of dust particles of the same specific weight and dispersion does not depend on the diameter of the pipe.

An analysis of the existing formulas for the transmission is given and it is shown that these formulas in case of a very fine dust, when the adhesion forces are predominant, are not valid. A new formula is proposed which is based on the assumption that the lifting force acting on a particle in a range of a laminar sublayer must be larger than the force of adhesion. This last is determined from the known Deryagin's formula [see *Zh. Fiz. Khimii* **6**, no. 10, 1935].

An empirical formula is proposed for practical use for the calculation of the transmission speed

$$v = \frac{75\,(\gamma D)^{1/6}}{\sqrt{b}}$$

where $\gamma$ is the specific weight of dust particles in g/cm³, $D$ diameter of the pipe in m, $b$ size of the dust particles in $\mu$.

I. E. Idel'chik

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**502. Romanenko, B. E., Problem on the motion of sediments** (in Russian), *Trudi Akad. Morsk. Flota* no. 4, 158–171, 1956; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6866.

Paper surveys briefly an extensive exposition, apparently also a survey, by the same author. A formal account of the discussions in 1950–1951 regarding the two directions taken by the problem of sediments opens the paper: the diffusion theory (V. M. Makkaveev and A. V. Karaushev) and the gravitation theory (M. A. Velikanov). The rest of the paper is taken up with a study of the diffusion theory. The deduction of the diffusion equation evolved by Makkaveev with a constant value for the coefficient of agitation has frequently appeared in the literature. Author only introduces into this equation a few unimportant items dealing with its precision: instead of the volumetric weight of the water he uses the volumetric weight of the mixture, leaving in operation two basic assumptions made by Makkaveev: (1) the constancy of the coefficient of the sediment and (2) the parabolic distribution of the velocities. Another solution is then put forward, that given by A. V. Karaushev, differing from the first in the following particulars; first, in the profile of the longitudinal velocities (not a parabola but an ellipse) and second, in the empirical computation of the heterofractionation of the sediments. Here also is introduced the simplification already referred to.

A numerical comparison is given, using an arbitrary example, of the calculation for the sediment content in accordance with Makkaveev and in accordance with Karaushev. In so far as the composition of the sediments in this example is viewed as monofractional, to the same extent Karaushev's empirical evaluation of heterofractionation has to be considered inapplicable. The concluding paragraph of the paper deals with the agitation coefficient. The author, quite erroneously, tries to demonstrate the linkage between the differences in the accepted profiles of velocity and the differences between the diffusion and the gravitation theories. Finally, the coincidence in practice of the formulas by Makkaveev and A. V. Karaushev is established.

M. A. Belikanov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**503. Gebhardt, H., Atomization with swirl nozzles, Parts I and II** (in German), *Maschinenbautechnik* **8**, 1, 33–39, Jan. 1959; **8**, 2, 83–91, Feb. 1959.

This paper covers essentially the same subject as the previous paper of the author: "Atomization with swirl nozzles" [AMR **12** (1959), Rev. 4200]. The nozzles were investigated mainly as regards their suitability for the atomization of heavy fuels, i. e., diesel oil, and tar oils from hard and soft coal. Flow rate, spray angle, and fineness of atomization were measured as functions of injection pressure, nozzle dimensions, and state of the liquid. Fineness of atomization was defined by the size of the largest drops. Flow coefficient of a nozzle could be expressed as a function of the Reynolds number. Drop size was found to depend mostly on injection pressure and on the viscosity of liquid. With the aid of the found relations, data obtained with water can be transferred to other liquids. Diagrams have been developed for designing nozzles for varied operating conditions.

K. J. DeJuhasz, USA

**504. Lyshevskii, A. S., Determination of jet length of atomised fuel** (in Russian), *Nauch. Trudi Nonocherkas. Politekhn. In-ta* **26**, 391–401, 1955; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 398.

The general equation is given for the length of jet (the depth to which the atomized fuel penetrates into a compressed air medium). The equation is checked by several experimental results published in the appropriate literature. Graphs are produced confirming the exactness of the relationship formula, which in general is based on theoretical considerations.

A. A. Gukhman

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**505. Mani, J. V. S., and Rao, M. N., Atomisation by pressure nozzles** (in English), *J. Sci. Engng. Res., India* **1**, 1, 113–118, Jan. 1957.

This is a progress report on an extensive investigation on the various aspects of atomization of fluids, dealing with the drop-size distribution of sprays produced by swirl-type nozzles. Liquified

naphthalene was used as liquid; on being sprayed the naphthalene solidifies, and the resulting globules are sized by sieving. Layout of apparatus, with electric heating, and the swirl-type nozzle are illustrated and described. Runs were made at 60, 80, 100 and 120 psig pressure with the liquid at 120 C. The sieving results were plotted as cumulative weight percent on a probability scale, versus square root of drop diameter; straight line relations were found.

Further experiments on the influence of density, viscosity, and surface tension are planned. Authors cite the previous work of V. Srinivas, V. Subba Rao, and M. Narasinga Rao, and also the treatise of E. Giffen and A. Muraszev "The atomization of liquid fuels." K. J. DeJuhasz, USA

## Porous Media

**506. Kolbuszewski, J., Stability of graded filters,** *Proc. Midland Soil Mech. Found. Engng. Soc.* **1,** Res. Pap. 4, 63–81, Apr. 1957.

In many civil engineering structures, especially in those built on permeable strata, there arises the necessity of constructing a filter which will allow percolating water to pass safely through without carrying away any particles of the protected soil, referred to as the "base material."

To ascertain the safe flow on one hand and the efficiency of a filter on the other, the grading of filter material must be properly chosen. In other words the grains of the filter must not be too large but neither can they be too small in relation to the base. In the first case, partially or completely washing out of the base material will take place; in the second, when the grains of the filter are too small, the flow of water will be impeded causing the filter to be only partially efficient. It is obvious that both cases are equally undesirable. If they are to be prevented, the filter must consist of a material with a grain size that meets certain requirements. In practice when it is desirable to reduce the loss of head due to percolation through the filter to a minimum compatible with the particle size requirements, large filters are usually made up of several layers. A filter of this composite type is known properly as a "graded filter." But in fact, the term is also used to describe any filter, even if it has only one layer, provided that its purpose is to protect the base from seepage erosion and it is designed in accordance with existing rules (Terzaghi).

From author's summary

**507. Karrholm, G., A flow problem solved by strip method,** *Trans. Chalmers Univ. Technol.* no. 208, 22 pp., 1959.

The slow, steady flow of a viscous fluid perpendicular to regularly spaced, infinite cylinders, is examined as an approximation to the flow of air through fibrous masses. Starting from the Navier-Stokes equations with inertia terms omitted, the problem is reduced to the solution of the biharmonic equation on the velocity potential, $\Delta^2\psi = 0$, with the relevant boundary conditions. It is known that a complete analogy exists between this flow problem and the determination of the deflection $w$ of an infinitely long thin plate, which also implies the solution of the equation $\Delta^2 w = 0$ being homogeneous when the plate is unloaded. Boundary conditions the same as for the flow equation result when the plate is simply supported and glued to equidistant semicircular rigid cylinders, with each cylinder rotated slightly around the support. The partial differential equations may be approximated by ordinary differential equations following a finite differences method proposed by author for the plate. The deflections may be calculated as analytic expressions in one rectangular coordinate for discrete values of the other (strips of the plate). The application to the flow problem is worked out through a numerical example, allowing determination of the permeability coefficient. Experimental values obtained by J. L. Shearer (unpublished) by electrical analogue compare favorably with those calculated by author's method.

A. Ghetti, Italy

**508. Huard de la Marre, P., Three dimensional electrical analogy for the study of seepage flow with free surface** (in French), *C. R. Acad. Sci. Paris* **240,** 23, 2203–2205, June 1955.

**509. Codreanu, D., A critical review of the investigations regarding the displacement of a gas-oil mixture by water** (in Roumanian), *Petrol si Gaze* **9,** 11, 485–488, Nov. 1958.

A critical review of the results of the laboratory investigations obtained by various authors, regarding displacement of an oil-gas mixture from a porous medium by water, as well as the importance of such a process in the oil recovery is presented.

From author's summary

**510. Rosenberg, M. D., Calculation of the exhaustion of petroleum deposits in the presence of dissolved gases** (in Russian), *Trudi Vses. Neftegaz. N.-i. In-ta* no. 10, 250–256, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2020.

Paper is an exposition of the theorem of the approximate integration of the relationship between pressure and petroleum saturation at the boundary of a stratum in the presence of gas in the latter, for the case in which the volumetric coefficient of the petroleum is not constant, as has been assumed in earlier works by the same author, but is a function of the pressure.

V. A. Arkhangel'skii
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**511. Rosenberg, M. D., Zinovieva, L. A., and Klyarovsky, G. V., The methodology of the hydrodynamic analysis of the yield of accompanying gas in conditions of gas saturation** (in Russian), *Trudi Vses. Neftegaz. N.-i. In-ta* no. 10, 257–265, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2021.

A method is described for calculating the yield of the accompanying gas from deposits containing dissolved gases, starting from a given (at any time) withdrawal of the petroleum; in the suggested method, the equation of the petroleum balance is applied, with a condition linking the average petroleum saturation of the stratum with the average pressure therein, varying during the process of extraction. This condition is obtained as a result of numerical integration of the relationship between the averaged values of saturation and pressure in the manner suggested by M. D. Rosenberg [see preceding review]. An example is given of the numerical calculation of the yield of accompanying gas, and considerations are presented on the verification and correction of such calculations from operational measurements.

V. A. Arkhangel'skii
*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**512. Kussakov, M. M., and Mekenitskaya, L. I., The thickness of thin layers of "bound" water** (in Russian), 4th Intern. Petroleum Congress, Moscow, Gostoptekhizdat, 1956, 261–271; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2026.

The results are presented of investigations on the thickness of layers of liquid in the following conditions: (1) Solid substratum-thin layer of water-gas; (2) solid substratum-thin layer of water-hydrocarbon liquid; (3) solid substratum-thin layer of water-petroleum. The experimental solid substrata were quartz and glass. Thin films were investigated of aqueous solutions of electrolytes, and various mining waters. The thickness of the films was determined by measuring their electrical conductivity. The film was formed on the wall of a capillary filled with the test liquid, by admitting an air bubble into the capillary, or a drop of hydrocarbon liquid, or a drop of petroleum. The experimental results show that, depending on the combination of contacting phases, a thin film may have both a positive and a negative cleaving effect. In the first case, it is stable and retains an equilibrium thickness for

an infinite time; in the second case the film is gradually displaced by the liquid contained in the droplet introduced into the capillary tube. The presence of the one or the other effect depends on the ratio of the surface tensions at the two interfaces of the film. The influence of electrolyte concentration and temperature on film thickness is investigated. S. V. Nerpin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**513. Namiot, A. Yu., The influence of gravity on the composition of stratified petroleums and water** (in Russian), *Neft. Kh-vo.* no. 6, 44–46, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2030.

A thermodynamic analysis is made of the change in concentration of solutions in a gravity field, and some examples relating to stratified petroleums and waters are examined. Conceptions of the great influence of gravity on the distribution of the different components in petroleum-bearing strata are critically examined and in particular reference is made to the errors in the paper by A. I. Khrebtov: "The distribution of gases in petroleum-bearing strata" [*Neft. Kh-vo.* no. 8, 43–46, 1955].

From author's summary

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**514. Gusseinov, V. P., Petroleum yield from strata with a gas cap with or without pressure applied to the gas** (in Russian), *Trudi Azerb. N.-i. In-ta po Dobytche Nefti* no. 2, 127–135, 1955; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2029.

The balance equations are given for the discharges of gas and petroleum, as well as the ratio between mean saturation of the porous space by petroleum and the mean pressure in the extraction of deposits with a gas cap. Curves are plotted for the mean weighted pressure values and the gas factor in relation to the degree of petroleum saturation, at different values of the ratio of pore volume within the region of the gas cap to the pore volume in the petroleum-bearing part of the deposit.

V. L. Danilov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**515. Tek, M. R., Grove, M. L., and Posttmann, F. H., Method for predicting the back-pressure behavior of low permeability natural gas wells,** *J. Petroleum Technol.* **9,** 11, 302–309, Nov. 1957.

The general problem of single-phase natural gas flow through porous media has been considered both by mathematical analysis and field experiments. Theoretical studies on the fluid dynamics of natural gas wells resulted in derivations of expressions which permit a better understanding of the flow mechanism for conditions under which Darcy's law is no longer valid.

In applying these results to natural gas production and testing technology, special emphasis was placed on the study of low permeability, slowly stabilizing formations. These applications resulted in a method of predicting the performance coefficients of tight natural gas wells.

The calculation of the performance coefficient requires the determination of the "test-index," $\frac{\pi kh}{\mu}$, the drainage radius $R$ and the effective wellbore radius $r_w$.

Methods for estimating these parameters from field data were also developed.

Field data from 15 wells were collected and analyzed. The measured values of the performance coefficients were compared with the predicted values. This statistical evaluation gave a bias of 7.14% and a standard deviation of 11.6%.

From authors' summary

**516. Cullender, M. H., and Smith, R. V., Practical solution of gas-flow equations for wells and pipelines with large temperature gradients,** *J. Petroleum Technol.* **8,** 12, 281–287, Dec. 1956.

**517. Fil'chakov, P. F., Horizontal and vertical ways of filtration** (in Russian), *Gidrotekh. Stroit.* **22,** 10, 25–30, 1953.

**518. Guerrero, E. T., and Stewart, F. M., How to determine effective permeability,** *Oil and Gas J.* **57,** 29, p. 112, July 1959.

**519. Guerrero, E. T., and Stewart, F. M., Determination of absolute permeability from well-test data,** *Oil and Gas J.* **57,** 27, 96–97, June 1959.

## Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 29, 30, 42, 251, 252, 280, 281, 348, 415)

**520. Malinovskaya, L. N., The dynamic features of longitudinal reflected waves beyond the critical angles** (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 5, 569–574, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4496.

Seismograms of reflected longitudinal waves for three- and four-stratified media are analyzed. From author's summary

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**521. Berzon, I. S., Some dynamic singularities of waves propagating in vertically laminated (stratified) media** (in Russian), *Trudi Geofiz. In-ta, Akad. Nauk SSSR* no. 35 (162), 51–87, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2095.

An examination of the dynamic singularities of sinusoidal and quasi-sinusoidal seismic waves, in reflection and refraction with normal incidence on an interface between two semispaces, and a vertical layer (stratum) enclosed between two semispaces. The interference phenomena are recorded in a large number of theoretical seismograms and theoretical hodographs of the phases and amplitude curves. Author investigates the nature of the relationship between these phenomena and the acoustic rigidities and absorptive capacities of the contacting media, as well as the frequency and duration of the oscillations. From experimental data and certain analytical conclusions, the possibilities are shown of utilizing the dynamic singularities of waves in the study of vertically laminated (stratified) structures in the presence of an enveloping medium.

K. I. Ogurtsov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**522. Aggarwala, B. D., and Saibel, E., A hypothesis of formation of mountains and continents,** Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 157–162.

Paper is concerned with an analytical approach to problem of initial formation of mountains in a spherically stratified visco-elastic Earth, initially just molten, and cooling from surface inward. For simplicity, viscosity is taken zero above melting point, infinite below. Using relevant geophysical numerical data, authors estimate that when cooling has led to formation of solid crustal shell in which critical stresses are reached, shell would start to buckle rather than fracture. K. E. Bullen, Australia

**Book—523. Press, H., editor, Handbook of water control [Taschenbuch der Wasserwirtschaft],** Hamburg, Verlag Wasser und Boden, Axel Lindow & Co., 1958, 729 pp.

This compendium on hydraulic engineering, prepared by 13 renowned authors, is designed mostly for municipal and agricultural engineers in Germany. Most important chapters: Properties of water, Climate and weather, Territory and soils, Water circuit, by A. Wechmann; Hydraulics, by M. Schmidt; Surveying and maps, by F. Hunger; Water regime, General planning of water control, by H. Press; Control of water quantity: agricultural and municipal engineering, by H. Press, H. Baumann, M. H. Olbertz and E. Gerlach; Sewerage and Fishing, by E. Gerlach and H. Mann; Water quality control: Water supply, by E. Nehring; Soil protection, by G. Allinger; Mechanical equipment of hydraulic engineering, by G. Grodau; Legal aspects of water control, by A. Wüsthoff.

Small, pocket-size book contains a great amount of brief information on different parts of the broad field of hydraulic engineering. It can be of interest for our readers as a presentation of the contemporary development of this particular part of hydraulic engineering. Well-selected bibliography contains German papers exclusively. Print and illustrations are of high quality.

S. Kolupaila, USA

**Book—524. Djounkovski, N. N., and Bojitch, P. K., Swell—its effect upon the coast and coastal structures [La houle et son action sur les côtes et les ouvrages cotiers]**, Paris, Eyrolles and Gauthier-Villars, 1959, 404 pp. 5 837 F.

Book consists of two parts, the first of which gives the wave theory as used in the USSR, while the second gives the engineering of coastal structures. The two parts are quite different in approach and maybe somewhat lacking in coordination. In general, book is clearly written, well illustrated, and logically organized. The theory and the construction methods are not identical with those used in the USA and, therefore, especially interesting to the American reader.

The wave theory, covering about the first 100 pages, is written with a rather theoretical approach. Formulas are used throughout rather than graphic descriptions, even for empirical relationships. This may have the danger of not sufficiently impressing the reader with the limits of application for such relationships. Only minor items in this part are not commonly available and currently used in the West despite the extensive quotes of Russian research. The methods of wave forecasting are not up to the latest state of our knowledge, which is easily explained by the fact that the original Russian text was published ten years ago.

The second part, which gives 200 pages of text and illustrations on the engineering practice of the USSR for coastal structures, is excellent in clarity, logic, and completeness. It has the distinct character of a textbook and may not be easily used as design manual since the authors do not give sufficient quantitative information in that part to actually design a structure. They leave the question fully open on how to choose block size for various structures, for instance, even if the theoretical part provides most of the background for it.

In summary, this book is excellent for the engineer or student who wants to familiarize himself with the general methods of planning, designing, and constructing coastal engineering structures.

H. A. Einstein, USA

**525. Dooge, J. C. I., A general theory of the unit hydrograph,** *J. Geophys. Res.* **64,** 2, 241–256, Feb. 1959.

Since its first proposal by L. K. Sherman over 25 years ago [*Engng. News-Record* **108,** 501–505, 1932], the unit hydrograph approach to stream flow prediction has developed into one of the most powerful tools of applied hydrology. The absence of a general theory of the unit hydrograph has, however, limited the scope of the method and made it dependent on personal judgment in its practical application. Author proposes a general theory which should help to remove many of the subjective elements from unit hydrograph analysis, and also to release the problem of synthesis from its present dependence on empirical relationships derived from localized data. The general equation of the unit hydrograph derived by the author seems to make essential progress in this field and will be always quoted in every new textbook on hydrology.

H. Arakawa, Japan

**526. Sackmann, L. A., and Feidt, R., Viscosimetry by the analysis of the law of flow discharge** (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 438–446.

Authors derive expressions for determining viscosity through measurement of the time rate of discharge from a reservoir. Expressions are given for the rate of drop in level for the case of transfer from one reservoir to another through a capillary. Both theoretical and experimental corrections are given for end effects which produce departures from Poiseuille's law.

W. C. Griffith, USA

**527. Vorontsov, P. A., and Shelkovnikov, M. S., Experimental aerological investigation of the lower atmospheric layer in the Azan valley** (in Russian), *Trudi Gl. Geofiz. Observ.* no. 63 (125), 138–167, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5580.

Factual data were obtained regarding the atmosphere's structure in the Azan valley. The observations were carried out between August 2 and September 10, 1954, in a round the clock series with reference to: aerostatic soundings up to a height of 1 km, ascents with a captive aerostat, apparatus with recording mechanism for the wind up to 500-m height, basic observations on pilot balloons and the release of equilibrated balloons. A brief account is given of the physical-geographical features of the region under observation, and the synoptic processes above the Caucasus and the Elbrus region at the time of the observations were described. An investigation of the wind regime in the Azan gorge was carried out, and also the structure of the air flow, the temperature and humidity of the air, differences in the courses of temperature and humidity in the free atmosphere and on the slopes of the valley, and local cloudiness. It is worth recording that because of the orography of the hill-valley circulation in the Azan valley the valley has a number of special features which distinguish it from analogous winds in other valleys, and establishes the possibility that because of this it often does not agree with the pattern of the theoretical scheme of Prandtl's structure of hill-valley circulation and with Defant's experimental scheme.

G. P. Kurbatkin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**528. Gubin, V. I., Change of some dynamical meteorological elements inside frontal zones** (in Russian), *Izv. Akad. Nauk UzSSR, Ser. Fiz.-matem. Nauk* no. 1, 53–73, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 841.

Vertical currents as well as variations of the temperature and of the geopotential altitudes of the isobaric surfaces are determined by the author from the equation of a vortex subscribed in the $p$-system

$$\frac{d}{dt}(\Omega \cdot \nabla T) - (\Omega \cdot \nabla)\frac{dT}{dt} = 0 \qquad [1]$$

where $\Omega$ = absolute vortex, $T$ temperature, $\nabla$ Hamilton's operator in the $p$-system, $t$ time.

The ageostrophical corrections to the horizontal component of the velocity vector of a wind are accounted only in the affluent heat equation

$$\frac{dT}{dt} - \frac{RT\gamma_\alpha}{g}\frac{\tau}{p} = \frac{q}{c_p} \qquad [2]$$

where $q$ = increment of heat in the unity time and mass, $\gamma_\alpha$ adiabatic gradient of the temperature, $p$ pressure, $g$ gravity acceleration, $c_p$ specific heat at constant pressure, $R$ gas constant.

Equation [1] in the geostrophical approximation can be written in the following form

$$\Delta\frac{\partial\Phi}{\partial t}-\frac{R}{P}\left(\frac{\partial T}{\partial x}\frac{\partial\tau}{\partial x}+\frac{\partial T}{\partial y}\frac{\partial\tau}{\partial y}\right)-l^2\frac{\partial\tau}{\partial p}-\frac{R}{p}\Delta T\tau=$$

$$-\left(\Phi,\frac{\Delta\Phi}{l}+l\right) \qquad [3]$$

where

$$\Delta=\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}$$

$$(A,B)=\frac{\partial A}{\partial x}\frac{\partial B}{\partial y}-\frac{\partial A}{\partial y}\frac{\partial B}{\partial x}$$

$\Phi$ geopotential; $l$ Coriolis' parameter.

The author, utilizing the statics equation

$$\frac{\partial\Phi}{\partial p}=\frac{RT}{p},$$

determines $\partial\Phi/\partial t$, $\partial T/\partial t$ and $\tau$ from the Eqs. [2] and [3] at the beginning with the geostrophical approximation and then introduces ageostrophical corrections, substituting the horizontal components of the wind velocities $u$ and $v$, in the heat increment equation, by the following expressions

$$u=-\frac{1}{l}\frac{\partial\Phi}{\partial y}-\frac{1}{l^2}\left[\frac{\partial^2\Phi}{\partial x\partial t}+\frac{1}{l}\left(\Phi,\frac{\partial\Phi}{\partial x}\right)+\tau\frac{\partial^2\Phi}{\partial x\partial p}\right]$$

$$v=-\frac{1}{l}\frac{\partial\Phi}{\partial x}-\frac{1}{l^2}\left[\frac{\partial^2\Phi}{\partial y\partial t}+\frac{1}{l}\left(\Phi,\frac{\partial\Phi}{\partial}\right)+\tau\frac{\partial^2\Phi}{\partial y\partial p}\right]$$

Sh. A. Musaelyan

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**529. Harteck, P., and Reeves, R. R., Jr., Utilization of energy stored in the upper atmosphere,** AFOSR TR 57-50 (Rensselaer Polytechnic Institute, Dept. of Chem. 50-9; ASTIA 136 421), 61 pp., July 1957.

The work is divided into two parts. First was an investigation to develop a flying missile, now called the HARE, to fly through the upper atmosphere within the region where oxygen atoms are present and most dense. The HARE is to be propelled by energy obtained by recombination of these atoms on a catalytic surface placed inside. The atmosphere would be scooped in, heated, and rush out the tail, pushing the missile forward.

The investigation included determination of a catalyst for the recombination, materials of construction, and various calculations indicating the feasibility of such a missile. Further equipment has been obtained to test various models of the HARE under simulated flight conditions.

As a second, more recent, part of the work a study has been started to determine more precisely the maximum oxygen atom concentration in the upper atmosphere. Several reactions must be considered of importance in consuming these atoms such as

$$O + O + M \longrightarrow O_2 + M$$

$$O + O_3 + M \longrightarrow O_3 + M$$

The results from experiments indicate that the rate coefficient for the second reaction involving the formation of ozone is equal to $5.7\ (\pm 0.2) - 10^{-34}$.

The entire work is being continued under Contract No. AF19(604)-2205 with the Air Force Cambridge Research Center.

From authors' summary

**530. Elliott, W. P., The growth of the atmospheric internal boundary layer,** *Trans. Amer. Geophys. Un.* **39**, 6, 1048-1054, Dec. 1958.

When air, whose wind profile is in equilibrium with an underlying surface, passes to another surface with different roughness, a layer is formed in which the air has adjusted to the new surface. Generally this layer will grow in depth downwind. Assuming the logarithmic wind-speed distribution and Karman's integral equation, the height of this layer is computed theoretically as a function of distance. A dimensional argument is also presented which qualitatively confirms the result that the boundary layer grows as the 4/5 power of the distance downwind and is independent of wind speed. The effect of thermal stability is estimated and found to be relatively small, raising the height of the layer in lapse conditions and lowering it in inversions. Some data are discussed which qualitatively confirm those results but which cannot be considered to be conclusive.

From author's summary by R. G. Fleagle, USA

**531. Spurr, G., The penetration of atmospheric inversions by hot plumes,** *J. Meteorol.* **16**, 1, 30-37, Feb. 1959.

Two formulas, proposed by Sutton and Priestley, are used to calculate the height to which a hot plume from a large power station will penetrate in a stably stratified atmosphere. The general conclusion (confirmed by later observation since publication of paper) is that the plumes can often penetrate inversions. But the theory only applies satisfactorily to cases of no wind, and even a light wind can bend the plume over into a regime of flow not considered in the paper. A notable difficulty in this problem is the absence of measurements of temperature in the lowest 500 meters of the atmosphere anywhere near large towns where pollution problems are severe.

R. S. Scorer, England

**532. Timofeev, M. P., Changes of temperature and humidity of the air above bounded water reservoirs** (in Russian), *Trudf Gl. Geofiz. Observ.* no. 59 (121), 53-60, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5572.

An examination is made theoretically of some cases of transformation of an atmospheric mass under the influence of an underlying surface. The heat and humidity exchanges are recorded in equations for stationary turbulent diffusion

$$u\frac{\partial q}{\partial x}=\frac{\partial}{\partial z}\left(u\frac{\partial q}{\partial z}\right) \qquad [1]$$

where $x$ is a horizontal coordinate directed parallel to the wind, the velocity $u$ of which and the coefficient of turbulence $k$ change with altitude $z$ in accordance with the limiting principles

$$u=u_1\left(\frac{z}{z_1}\right)^e, \qquad k=k_1\left(\frac{z}{z_1}\right)^{1-e} \qquad [2]$$

The second formula of [2] contains an error, $g$ is the humidity or temperature. The distribution of $q$ when $x=0$ ($q=q_1$) is taken to be known. The cases examined differ from each other by the form of the given distribution of $q_0$ on the underlying surface when $z=0$. The known (and simplest) case, $q_0=\text{const}$, is briefly analyzed to start with. Here the relative transformation at a given point $\sigma=(q-q_1)/(q_0-q_1)$ is the same for humidity $\sigma'$ and for temperature $\sigma''$. Then a variant is investigated of the linear increase or decrease in the temperature of the underlying surface and, correspondingly, of the humidity on it. In this case $\sigma'$ and $\sigma''$ may differ from each other. It is more natural to assume that in the case of cold advection the temperature of the underlying surface increases with increase of distance from the shore, while in the case of heat advection there would be a decrease. Then $\sigma''>\sigma'$, which agrees with the results of analysis of the observations. The case is also examined where the temperature and humidity distributions on the underlying surface are described by means of

parabolic principles. This case is characteristic of conditions where, because of the effect of the depth of the reservoir, the temperature on its surface (and consequently the saturating humidity) near the shore is different from the temperature in the center of the reservoir. L. S. Gandin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**533. Kirillova, T. V., and Ogneva, T. A., Features of the thermal balance of a water surface** (in Russian), *Meteorol. i Gidrol.* no. 4, 41–46, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5578.

Paper consists of an analysis of the results of the observations by an expedition of the Principal Geophysical Observatory on the components of thermal balance of the surface of the Tsimlyansk reservoir, in July 1954. The numerical material obtained for these components was analyzed and the magnitudes determining them. A comparison was made with the values of the same magnitudes for a dry surface. The following deductions were drawn: (1) When determining the reflection factor of the water surface it is essential to take into account correctly its diurnal course. Replacement of the actual mean loaded diurnal value of the reflection factor by its mean arithmetical value leads to an error of the order of 2.5%. (2) On an average the radiation balance of the water surface is larger than of the dry land principally because of the difference in the reflection factor. (3) The part played by the turbulent heat flow in the atmosphere is significantly less in the thermal balance of a water surface than of a land surface. (4) The diurnal course of evaporation from the water surface is not great. In the daytime the relevant consumption of heat is compensated by the radiation balance; at night time, mainly by the thermal flow from the depths of the reservoir. L. S. Gandin

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

## Naval Architecture and Marine Engineering

(See also Revs. 157, 364, 462)

**534. Kaplan, P., and Hu, P. N., Virtual mass and slender-body theory for bodies in waves,** Proc. 6th Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. of Texas Press, 1959, 183–197.

Potential flow near a long, thin submerged body is analyzed. Body is moving relative to the water and in a direction oblique to a system of surface waves. Velocity potentials are computed using the slender-body assumptions, see AMR **11** (1958), Rev. 3852. For several particular cases the pressure distribution on the surface of the body is evaluated. The various forces and moments on the body are then found from an integration of pressure over the surface. Cases considered are a body of revolution without fins, with symmetrical fins, and with a single vertical fin. Because the treatment of the problem is two-dimensional, bodies of cross section other than circular can be analyzed by conformal mapping methods. From the final solutions, author demonstrates that the force on any cross section is due to two components. The first is the rate of change of fluid momentum and the second is the force arising from the pressure gradient across the body.

W. D. Baines, Canada

**535. Silberman, E., Experimental studies of supercavitating flow about simple two-dimensional bodies in a jet,** *J. Fluid Mech.* **5**, 3, 337–354, Apr. 1959.

The advantages of a free-jet test facility for model studies of supercavitating hydrofoils are well documented in this paper. Measured force coefficients for inclined plates, circular cylinder, wedge and cup forms are compared with theory and with results of tests in closed water tunnels. The characteristics of supercavitating bodies in an infinite fluid are shown to be given correctly by the tests in a free jet for all except the lowest cavitation numbers. D. W. Appel, USA

**536. Sivers, N. L., Investigation of the mutual action of general deflection of a ship's hull and deflection of the bilge cross beams and the participation in these of the bottom sheathing and the deck of the second bottom** (in Russian), *Trudi Leningr. Korablestroit. In-ta* no. 18, 23–34, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5957.

The stressed condition is investigated of the bottom sheathing and the deck of the second bottom of a ship when taking into account the fact that these components of the hull appear to be belts of the cross beams and the equivalent bracing and are being subjected to plane stresses. The problem is solved on the assumption that the deformation in the cross section of the hull conforms to the hypothesis of plane sections. A. A. Kurdyumov

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**537. Criscuolo, E. L., Isotope techniques for inspection and evaluation of ship welds,** *Welding J.* **38**, 8, 324s–328s, Aug. 1959.

The inspection of a weld depends upon a method of detecting flaws and having enough information to determine the significance of the flaw on the welded structure. The information obtained by the flaw-evaluation program assists in the interpretation and evaluation of the radiograph. Although other fast and inexpensive inspection methods are being investigated, radiography with isotopes has demonstrated its capabilities as a flaw-detection method. From author's summary

## Friction, Lubrication and Wear

(See also Revs. 31, 196, 207)

**538. Steijn, R. P., Sliding ware and metal transfer under unlubricated conditions,** *Trans. ASME* **81**D (*J. Basic Engng.*), 1, 67–78, Mar. 1959.

To provide further information on dry sliding wear and the accompanying metal transfer, wear experiments of radioactive brass rings against hardened steel have been conducted in a ring tester. The effect on metal transfer of sliding speed, surface finish, material of the harder surface, and the presence of slots in the steel ring have been investigated. Tests have also been conducted in argon atmospheres to exclude oxidation.

Wear of brass on brass has been investigated by using radioactive rings against inactive rings. Results indicate a complex wear mechanism in which transfer, back transfer, and removal of transferred material are intermediate steps, and in which the determining step in wear rate is governed by the geometry of the rings rather than the apparent area of contact.

From author's summary

**539. Yamasita, S., On the influences of the finishing condition of the surface of metallic plate upon the abrasion of metals by the fluid with sand particles,** *Bull. JSME* **2**, 5, 29–34, Feb. 1959.

Author refers to his study on the influences of the finishing conditions of metallic plate surfaces upon the abrasion of metals to the fluid with sand particles.

The working direction of file on the final finishing surface of metallic plate is set so that it has an angle of 90° to the flowing direction of the fluid with sand particles. Finishing conditions are: (1) the state of as-cast black sheet; (2) bastered file finish; (3) dead-smooth file finish; (4) emery paper 5 finish; (5) emery

paper 3 finish; (6) emery paper 1 M finish; (7) emery paper 0/2 finish; (8) emery paper 0/4 finish; (9) emery paper 0/6 finish; (10) buff finish.

Surface conditions of metallic plate just before and after the experiment of abrasion were examined with a surface tester, and surface roughness was measured. From author's summary

**540. Vaidyanath, L. R., Das, B. N., and Bucknall, E. H., Wear due to rolling friction** (in English), *J. Sci. Engng. Res., India* **1,** 2, 169–184, July 1957.

Experiments have been made to evaluate wear due to rolling friction using an "Amsler" wear tester. Materials employed in rails and railway tires and wheels were tested. Although a few tests were made under (nominally) pure rolling conditions, in most of the tests 10% longitudinal slip and controlled to and fro lateral motion of the specimen were included, the latter to simulate service conditions. Influence of load and speed has been studied for a particular combination of materials, e.g. medium manganese rail steel against wheel or tire steel. The wearing qualities of different rail materials have also been compared. It has been observed that the kinetic friction and the rate of wear were high in the initial stages of test, but both decreased subsequently, presumably due to work-hardening of the mating surfaces. Wear products produced during test appeared to have an important effect in accelerating wear rate, dulling and roughening the mating surfaces and increasing friction and the depth of cold work. From authors' summary

**541. Kuznetsov, N. V., Ash abrasion of pipes and the critical speed of gases in boiler units** (in Russian), *Teploenergetika* **4,** 18–23, 1955; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 380.

A method is proposed for the quantitative determination of coefficients in the formula expressing intensity of abrasion of the pipe surface by ash. Author quotes figures for critical values of the gas speed in the convecting shafts of the upper packets of the heating spiral-surfaces of the boiler unit.

The proposed values for the speed appear somewhat lower than those used for design at present. The explanation lies in the fact that author assumes less favorable conditions than those which have been assumed before. V. F. Laditskii

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**542. George, R. E. W., Viscosity characteristics of lubricating oils at high speeds of slip** (in Russian), 4th International Mezhdunaroohiyi Neft. Kongress, Moscow, Gostoptekhizdat, 1957, 146–152; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 928.

The relation between viscosity, temperature and speed of slip for a series of lubricating oils is determined by means of the capillary viscosity-meter at a pressure and the rotary viscosity-meter with a conical plug. As the viscosity was being measured, the temperature of lubricating oils was changing from -35 to 100° and the speed of slip was up to $10^6$ $sec^{-1}$. It was found that the viscosity of oils containing additions of the polymer type, which improve the index of viscosity, drops considerably at slip speeds of the order of $\sim 10^6$ $sec^{-1}$ and approaches the value of viscosity of the base mineral oil. Oils with an addition of polymers behave as non-Newtonian liquids throughout investigated range of temperatures. Oils without any polymer additions behave as non-Newtonian liquids at temperatures near their solidification temperature. In addition to this their viscosity decreases with increasing speed of slip. Experimental curves are presented of relationships between viscosity, temperature and speed of slip for series of lubricating oil. A. I. Golubev

*Courtesy Referativnyi Zhurnal, USSR*
*Translation, courtesy Ministry of Supply, England*

**543. Burgdorfer, A., The influence of the molecular mean free path on the performance of hydrodynamic gas lubricated bearings,** *Trans. ASME* **81D** (*J. Basic Engng.*), 1, 94–100, Mar. 1959.

Modified Reynolds equation is derived for bearings with slippage assumed between gas molecules and bearing surfaces. Closed solutions for two-dimensional flow are given for Rayleigh-type step bearing and an inclined slider bearing.

From author's summary by W. J. Anderson, USA

**544. Reichenbach, G. S., Accinelli, J. B., and Beaubien, S. J., Lubrication of high-speed high-temperature thrust ball bearings,** *ASLE Trans.* **1,** 2, 259–265, 1958.

Friction and surface damage due to high-temperature effects on operation of high-speed axially loaded ball bearings are investigated. Small-scale operating conditions are chosen to give ball-to-surface temperatures approaching corresponding temperatures for full-scale bearings. Instantaneous surface temperatures due to sliding friction only are considered and computed as for a moving heat source on a semi-infinite body and modified by cooling effects of oil. Experiments were performed with 25-mm angular contact ball bearings driven at 40,000 rpm by air turbine; thrust load of 200 lbs. With a once-through jet lubrication system with silicone fluid, mineral oil and a synthetic ester lubricant, friction failures occurred at approximately 350F, 650F and 800F respectively. Recirculated mineral oil became extremely viscous and heavy deposits occurred, but failure occurred at about the same temperatures. With oil mist lubrication failure occurred at a much lower temperature, probably due to insufficient lubricant to provide for hydrodynamic component of mixed friction at contact zone or to failure to provide lubricant due to excessive oil volatization. Two EP additives used in conjunction with mist lubrication did not give appreciable improvement, probably because of stainless steel test bearings. C. F. Kettleborough, New Zealand

**545. Sasaki, T., Mori, H., and Hirai, A., Theoretical study of hydrostatic thrust bearings,** *Bull. JSME* **2,** 5, 75–79, Feb. 1959.

At first authors give the formulas for the caluclation of the pressure distribution, the load capacity, and the quantity of flow in spherical, discal, and conical hydrostatic thrust bearings. In deriving these formulas the centrifugal force and squeeze film have been disregarded. In order to estimate the influence of these effects authors consider the discal bearing. Calculating an example mentioned by D. D. Fuller they state that the effect of the centrifugal forces can involve a reduction in the load capacity by 33%, and that therefore this effect must be taken into account in bearings operating at high speed. The effect of the squeeze film originating from approach of the bearing surfaces results in an increase in the load capacity which is inversely proportional to $h^3$ ($h$ = bearing clearance). Therefore good damping can be obtained by choice of a small bearing clearance $h$.

In the remaining part of the paper authors disregard both effects and examine what values are to be chosen for the bearing clearance, the restrictor, the pocket, and the supplying oil pressure in order to get optimum dynamic stability, maximum load capacity, and minimum power consumption. All optimal values cannot be realized at the same time. The realization of maximal load capacity and optimum dynamic stability requires another dimensioning of the pocket than the realization of minimum power loss combined with optimal dynamic stability. The conditions essentially depend on the kind of restrictor, whether it is a capillary or an orifice.

U. Rost, Germany

**546. Chou, Y. T., and Saibel, E., Effect of turbulence on slider-bearing lubrication,** *J. Appl. Mech. (Trans. ASME,* Series E) **26,** 1, 122–126, Mar. 1959.

Using Reynolds equations of motion for turbulent flow and an expression for fluctuating velocity components similar to Prandtl's

mixing length hypothesis, slider bearings with no side leakage operated in the turbulent regime are analyzed. In addition to the usual assumptions common to lubrication studies, an approximate solution is obtained by taking the first two terms of power expansions of some functions. It is found that the turbulent effect increases both the load capacity and power losses of the bearing.

L. N. Tao, USA

**547. Vasavada, P. A., The load characteristics of a stepped bearing** (in English), *J. Sci. Engng. Res., India* **1**, 1, 97–102, Jan. 1957.

Calculated values of load capacity of stepped slider bearings and journal bearings using Archibald's formulas [AMR **4** (1951), Rev. 4668] are presented in tabular and graphical form. It is pointed out that load capacity increases rapidly with decrease in film thickness but reviewer points out that this can also be due to increase in width of bearing. Computations for half and full journal bearing clearly show that high load capacity is associated with thin oil films.

C. F. Kettleborough, New Zealand

**548. Deryagin, B. V., Karasev, V. V., Kakhavaeva, N. N., and Lazarev, V. P., The mechanism of boundary lubrication and properties of the boundary lubrication layer** (in Russian), *Zh. Tekh. Fiz., Akad.* Nauk SSSR **27**, 5, 1076–1086, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5435.

Bowden's statement [F. P. Bowden, D. Tabor, "The friction and lubrication of solids," Oxford, 1954] to the effect that the boundary layers of a liquid contiguous to a solid wall at a distance from it of less than $1\mu$ do not possess specific viscous properties is criticized. A description of experiments is given for the determination of the distribution of velocities of the motion of lubricants near a solid wall during shear. The investigation was carried out by the method of blowing off by means of an air flow of a layer of oil from a flat wall. The current of air flowed between two parallel plane walls placed at a distance of 0.2 mm from each other. A layer of oil $10\mu$ thick was put on to the lower wall. After the blowing of air for a determined period of time through the slit formed by the two planes, the layer of lubricant acquired variable thicknesses in relation to the distance to the wetted line. The thickness of the layer of lubricant was measured (with a precision of 5A) by means of illuminating the plate with polarized light, the modulation of which was strengthened when reflected, and fixation by means of an oscillograph. It was reckoned that some constant force of friction is transmitted from the air to the lubricant layer, and that consequently the layer of lubricant is exposed to the action of pure shear. From this point, knowing the variation in the layer's thickness and the duration of the blowing through of the air, the determination of the distribution of velocity in the layer of oil is proceeded with. It should be noted that this type of investigation does not take into account the influence of the pressure of the air on the motion of the layer of oil and the changes appearing in the airflow through the slit when air was blown through the layer of oil. Curves were obtained to show the distribution of velocity in the layer for a pure vaseline lubricant, for a vaseline lubricant with additions of chloroparaffins, benzontrone, phthalic-dibutyl-ether, etc. The curves show that the influence of the wall on the viscosity coefficient of the liquid spreads to a thickness of up to $0.1\mu$. With some liquids on approach to the wall the viscosity increases, with others it falls. The viscosity of pure vaseline lubricant is unaffected by the wall. The experiments also showed that the boundary layer does not possess the limiting stress of shear. For the expression for the static friction of the planes, separated by a boundary polymolecular layer, a two-term formula is proposed, the first item of which is proportional to the load on the plane, while the second characterizes the molecular attraction between the planes. The physical essentiality of the first item is not demonstrated.

A. I. Golubev

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## Books Received for Review

BERSHADER, D., edited by, The magnetohydrodynamics of conducting fluids, Stanford, Calif., Stanford University Press, 1959, viii + 145 pp. $4.50.

BYERLY, W. E., An elementary treatise on Fourier's series and spherical, cylindrical, and ellipsoidal harmonics with the applications to problems in mathematical physics, New York, Dover Publications, Inc., 1959, ix + 287 pp. $1.75 (Paperbound).

CARMICHAEL, R. D., The theory of numbers and Diophantine analysis (two books bound in one volume), New York, Dover Publications, Inc., 1959, 94 pp.; vi + 118 pp. $1.35 (Paperbound).

CHAMPION, F. C., and DAVY, N., Properties of matter, third edition, New York, The Philosophical Library, Inc., 1959, xvi + 334 pp. $10.

COOLIDGE, J. L., A treatise on algebraic plane curves, New York, Dover Publications, Inc., 1959, xxiv + 513 pp. $2.45 (Paperbound).

DICKSON, L. E., Algebraic theories, New York, Dover Publications, Inc., 1959, ix + 276 pp. $1.50 (Paperbound).

EICHNER, H., and HEIN, H., Reading German for scientists, New York, John Wiley & Sons, Inc., 1959, xi + 207 pp. $4.25.

FAITH, W. L., Air pollution control, New York, John Wiley & Sons, Inc., 1959, vii + 259 pp. $8.50.

GAJCZAK, S., Absorpcyjne Urzadzenia Chlodnicze, Warszawa, Panstwowe Wydawnictwa Techniczne, 1958, 167 pp. + tables. Cena zl. 21 (Paperbound).

GRABBE, E. M., RAMO, S., and WOOLDRIDGE, D. E., edited by, Handbook of automation, computation and control, Vol. 2, Computers and data processing, New York, John Wiley & Sons, Inc., 1959, xxiii + 833 pp. + index. $17.50.

GUNDER, D. F., and STUART, D. A., Engineering mechanics, New York, John Wiley & Sons, Inc., 1959, xi + 391 pp. $7.75.

HECHT, F., editor, IXth International Astronautical Congress Proceedings, Vols. I and II, Wien, Springer-Verlag, 1959, xii + 970 pp. $49.50 (the set).

HOLLINGDALE, S. H., High speed computing methods and applications, New York, The Macmillan Co., 1959, xii + 244 pp. $5.

HOUGEN, O. A., WATSON, K. M., and RAGATZ, R. A., Chemical process principles, Part two, Thermodynamics, second edition, New York, John Wiley & Sons, Inc., 1959, xviii + 505–1072 pp. + indexes. $9.75.

JAKUBOWSKI, T., Analize Wymiarowa Zamiennosci Czesci, second edition, Warszawa, Panstwowe Wydawnictwa Techniczne, 1958, 214 pp. Cena zl. 20 (Paperbound).

KIRILLOW, I. I., Regelung von Dampf- und Gasturbinen, Berlin, VEB Verlag, 1956, 395 pp. DM 30.

KOWALCZEWSKI, S., Urzadzenia Chlodnicze, Warszawa, Panstwowe Wydawnictwa Techniczne, 1955, 315 pp. + tables. Cena zl. 35.

KUTATELADZE, S. S., BORISHANSKII, V. M., NOVIKOV, I. I., and FEDYNSKII, O. S., Liquid-metal heat transfer media (Translated from the Russian), New York, Consultants Bureau, Inc., 1959, 149 pp. $22.50.

L'HERMITE, R., Methodes generales d'Essai et de Controle en Laboratoire, Vol. 1, Mesures Geometriques et Mecaniques (Traite d'expertise et d'Essais des Materiaux et des constructions), Paris, Eyrolles, 1959, xii + 739 pp. 9 700 F.

LOVEJOY, C. E., College guide, enlarged fifth edition, New York, Simon and Schuster, Publishers, 1959, 290 pp. $4.95.

LUTZ, O., and WOLF, F., JS-Tafel fur Luft und Verbrennungsgase, Berlin, Springer-Verlag, 1959, 18 pp. + 4 small and 1 large nomogram. DM 14. complete.

MEEBOLD, R., Die Drahtseile in der Praxis, third edition, Berlin, Springer-Verlag, 1959, 110 pp. DM 12. (Paperbound).

MIKOSZEWSKI, J., Maszyny i Przyrzady Wytrzymalosciowe Eksploatacja i Sprawdzanie, Warszawa, Panstwowe Wydawnictwa Techniczne, 1957, 318 pp. Cena zl. 29.

NIKIEL, T., Turbiny Parowe, Warszawa, Panstwowe Wydawnictwa Techniczne, 1956, 327 pp. Cena zl. 16.70 (Paperbound).

OCHEDUSZKO, K., Kola Zebate, Tom 3, Sprawdzanie, second edition, Warszawa, Panstwowe Wydawnictwa Techniczne, 1957, 200 pp. Cena zl. 35.

OCHEDUSZKO, S., Teoria Maszyn Cieplnych, Part 1, Podstawy termodynamiki Technicznej, second edition, Warszawa, Panstwowe Wydawnictwa Techniczne, 1957, 455 pp. + 15 tables + index. Cena zl. 92.

RASSWEILER, G. M., and GRUBE, W. L., edited by, Internal stresses and fatigue in metals (Proceedings of the Symposium on Internal Stresses and Fatigue in Metals, organized by the General Motors Research Laboratories, Detroit, Mich., 1958), Princeton, N. J., D. Van Nostrand Co., Inc., 1959, x + 451 pp. $11.

SAARE, E., and WENNER, C.-G., Varmeledningstal hos olika jordarter, Handlingar nr. 31, Stockholm, Sweden, Statens Namnd for Byggnadsforskning, 1957, 136 pp. 8 a-pris.

SCHRODER, K., Grosse Dampfkraftwerke Planungs, Ausfuhrung und Bau, Vol. I, Kraftwerksatlas, Berlin, Springer-Verlag, 1959, xv + 1073 pp. DM 192.

SEMENOV, N. N., Some problems of chemical kinetics and reactivity, Vol. 2, second revised edition, (Translated from Russian by J. E. S. Bradley), New York, Pergamon Press, Inc., 1959, 168 pp. $5.

SHIGLEY, J. E., Kinematic analysis of mechanisms, New York, McGraw-Hill Book Co., Inc., 1959, x + 351 pp. $7.75.

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